



THE CLIMATE OF MANITOBA

BY
A. J. LAMBERT

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The Honourable John Bracken,
Premier of Manitoba.

Sir:

I have the honour to submit herewith a report on The Climate of Manitoba, being Project No. 15 under the Economic Survey, and the sixteenth of a series of reports covering many phases of the economic and social life of the province. This report is the work of Mr. A. J. Connor, Meteorological Service of Canada, Department of Transport, Toronto, Ontario.

This study was made possible through the co-operation of the Hon. C. D. Howe, Minister of Transport, Ottawa.

I have the honour to be, Sir,

Your obedient servant,

H. C. GRANT,

Acting Director.

Winnipeg, Manitoba,
February 16, 1939.

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BY

A. J. CONNOR

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DEPARTMENT OF TRANSPORT

TORONTO, ONTARIO

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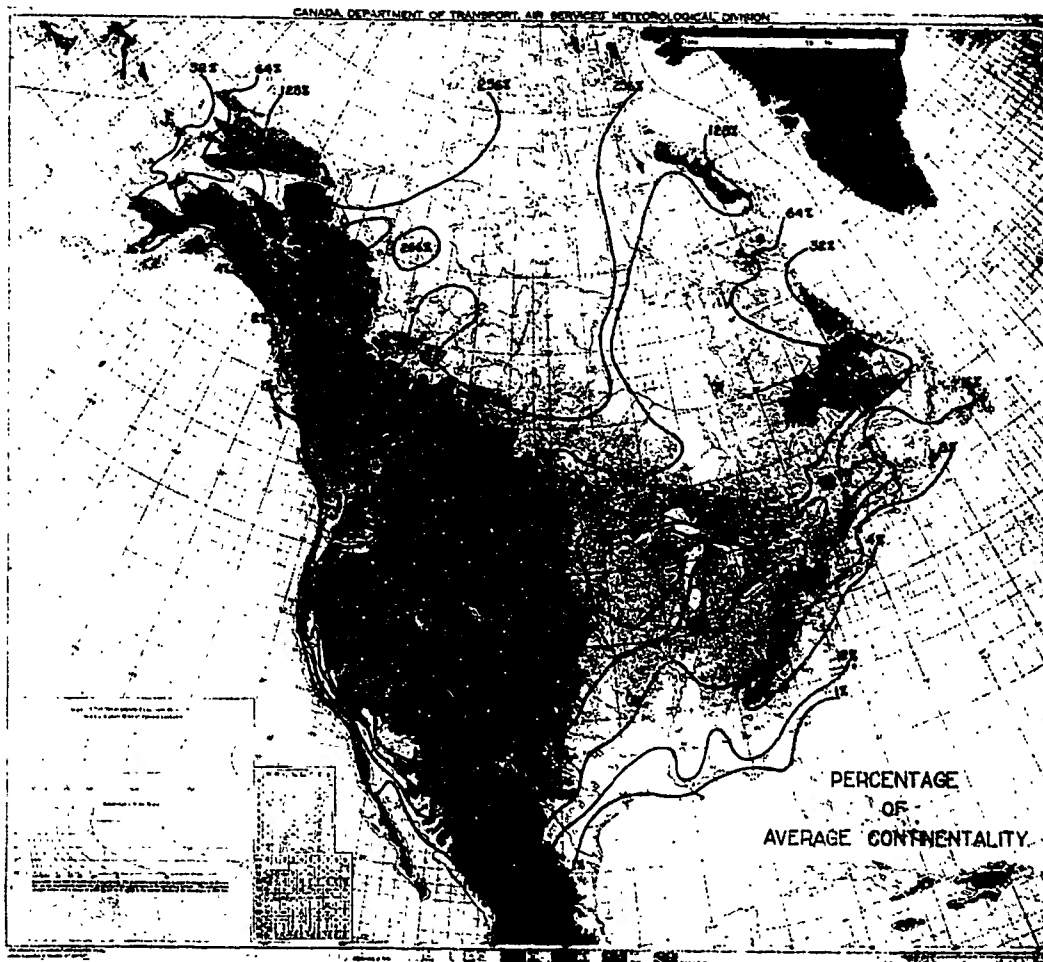
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THE CLIMATE OF MANITOBA

CHAPTER I

Historical and Introductory

(1) The first meteorological records in Manitoba were made one hundred and sixty-six years ago by Thomas Hutchins, an officer of the Hudson's Bay Company at York Factory, near Port Nelson on Hudson Bay. None of these records of 1772 and 1773 are now available for examination in Canada but are believed to be in the London archives of that ancient company.

(2) Although records of the weather began in the most northerly portion of the province nearly two centuries ago, there have been very few made in the north since that time and few are being made there to-day. There are meteorological stations to-day at Churchill, God's Lake, Flin Flon, The Pas, Norway House, and about 1840 there were records recommenced at York Factory and Port Nelson, while for a few months in recent years observations were taken at Herb Lake and Pakitawagan. The northern data have been barely sufficient to delineate the general climatic features of the largely unsettled region which lies north of the Great Lakes of Manitoba.

(3) In southern Manitoba meteorological observations began when the Meteorological Service of Canada was first being organized as a dominion-wide weather-survey between the years 1869 and 1871. The late Archbishop Machray assisted in finding observers in those early years. St. John's College began observations in August, 1872, but James Stewart had commenced at Fort Garry in 1871. By 1879 there were stations at Poplar Heights under A. C. O'Bierne and J. Spiers; at Emerson under the Rev. Mr. Jukes; at Manitoba Penitentiary, S. L. Bedson; and Ossowa, W. H. Turton. At York Factory the observations commenced in 1840 were being carried on by W. Wood while readings of temperature at Gimli by J. Taylor and of rain by A. K. McKenzie at Fort Alexander were contributed to the Annual Reports of 1879. In the reports of the Meteorological Service a list of the observers from the earliest times to the present together with the length of record will be found.

(4) For fairly complete coverage of the province there should be a meteorological station reporting at least temperature and precipitation for every six townships and seven ranges. That would give a station for each area of approximately 1500 square miles. Since Manitoba has an area of 246,512 square miles, we should have about 165 stations to afford basic material for a climatic survey. The greater part of the province is at present so sparsely populated that such a program of observations is not yet feasible.

(5) "Climate" as a word began with the Greek *κλίμα*, a slope. Various differences in the growth of trees and plants, in the time of fruiting and ripening, in the flavor of edibles and the bouquet of wines, and in the comfort of people and animals doubtless engaged the attentive speculation of early Greek agriculturists. Probably the comparative advantages and disadvantages of slopes facing north and east, or south and west, of slopes at high elevations or of slopes near the sole of the valley, were discussed with much argument about the variation of sunshine and wind, and drainage of air and water in relation to slope and earliness or quality of crops. At least such discussions may be heard often to-day in the valleys of British Columbia where the merits of lower, middle and high "benches" or slopes are often the subject of conversation or of writing. No doubt this was so centuries ago in Greece and so the "climatic" or "slope" features of a piece of cultivated soil, from involving at first some considerations of the effect of weather upon the slope, became by gradual changes in usage of speech at last a criterion of the beneficence of the weather-sequences upon the land no matter which way it sloped nor whether there were any slope at all.

(6) As a first step towards a survey of the climate of Manitoba, it will be useful to enquire what is its position in relativity to the fundamental features of other North American climates. This will require some fundamental units by which all can be measured simultaneously. From every point of view of climate where so many considerations of growth, health, national economy, etc. are involved no formula of measurement will be universally satisfactory. Many have been proposed and by adjustment to the data of a given region from a limited point of view can be made to serve well within their particular limits; but when carried to regions whose climates

were not considered in the original conception these formulae are not eminently suitable. Such formulae are those which are adjusted to suit the northern limit of growth of the palm and the olive, the vine, the birch, beech, and conifers and wheat in Europe. Transferred to North America, they fail to meet with universal approval.

(7) If we decide to start afresh, giving thought at first to our own continent only, we may think first of these fundamentals (a) coastal climate (b) mid-continental climate (c) mountain climate. If the continent is divided by these three measures, there can be no remainder. There are, however, quite evidently some zones where these climates overlap or at least where no line of demarcation is plainly evident. We are, therefore, driven to considerations even more fundamental than these three easily recognized types of climate.

(8) Coastal climates are chiefly differentiated from continental climates by the large content of water-vapour held in the lowest layers of airmasses approaching the coast from the sea. The high mixing-ratio of dry air and water-vapour serves to retard the loss of heat at the surface of the soil by radiation outward to the sky, and to retard the gain of heat through insolation by the rays of the sun. Therefore, coastal climates are distinguished principally by comparatively small changes in temperature of the air from day to night and from winter to summer. It will be difficult to deny this is the unique characteristic of a coastal climate. Raininess is, for instance, not an unique characteristic of a coast since rain is not dependent upon the water-vapour content of an airmass but upon the convergence of rapidly and sufficiently cooling airmasses containing water-vapour to a point in the free air above the coast. If such a movement is lacking, there will be no rain upon the coast while such a movement will produce rain in the interior of a continent. More specific instances are the well-known dry summers of the British Columbian coast, the aridity lasting for years at a time of the Ceara district on the Brazilian coast, the recurring droughty years experienced even on tropical islands. Neither can winds, sunshine or clouds be used to particularly delimit coastal climates for these phenomena are dependent upon airmass movements which can and do take place equally well in the interior of the continent. Thus, the interchanges of land-breezes and sea-breezes on the coasts do not differ essentially from the interchanges of upvalley and downvalley winds of an alpine region, since both are actuated by diurnal rise and fall of isosteric surfaces. We are left with the high water-vapour content and the consequent small diurnal and annual range of temperature as the criteria of the littoral factor in climate.

(9) In contradistinction to the littoral factor, the continentality of a climate must be gauged by diminishing water-vapour content in the lowest layers of the atmosphere. On the North American continent water precipitated from the atmosphere and draining away by the rivers to the sea must be renewed by water-vapour transported in airmasses moving inland from the Pacific, Atlantic and Arctic Oceans. The water-vapour abstracted from the Great Lakes of the Mackenzie, of Manitoba and of the St. Lawrence by airmasses below the saturation point delays in their neighborhood the process of desiccation but alone contributes only in small measure to humidification. This is easily evident if one considers what would happen if moisture from the oceans were no longer transported inland. The rivers draining these lakes would then in a very short time take all their water to the sea and then there would be no water surfaces remaining on the continent. It is, therefore, obvious that all inland waters of lakes and streams are brought by airmass transport from the oceans.

(10) The ability of an airmass to pick up and to carry water-vapour is directly dependent upon the temperature of the air. Therefore, comparatively cold air can pick up little water-vapour and cooling air may be cooled to the point where the heat is insufficient for the retention of the water in the vapour-form with consequent condensation and the appearance of fog, mist, or cloud. Also the rate at which water-vapour is freed from a body of water is dependent upon the temperature of the surface-skin of water-molecules. For both these reasons the greatest transport of water-vapour to the continent must be from the tropical regions of ocean and the least transport from the arctic regions of ocean, while other oceanic areas can contribute at intermediate rates.

(11) The very warm surface waters of the Caribbean Sea and its extension into the Gulf of Mexico set free water-vapour at a rapid rate while the airmasses traversing these waters with large components of motion towards the north and west also have a high content of heat in the lowest levels. The result is a large transport of water-vapour above the southern regions of North America. When there is a reversal of air movement so that comparatively dry air moves

to the south and east from the land out over these waters, meteorological stations upon islands in the gulf will, obviously, measure a smaller content of water-vapour. Averaging all measurements regardless of direction of air movement, we find for Key West, a small island off the southern tip of Florida, the average ratio of water-vapour to dry air to be in July, 1936 about $18\frac{1}{2}$ grams of vapour to 1000 grams of dry air and in January about 14 to 1000. These ratios are not far from the normal values determined from about forty years of observation.

(12) On the Pacific coast we find for San Francisco the average vapour-content to be for January at local noon about $5\frac{1}{2}$ grams per kilogram and in August about 9 grams per kilogram and somewhat lower for the mean of the twenty-four hours. At Prince Rupert on the British Columbian coast we find an average ratio of 3.9 per 1000 in January and of 8.5 per 1000 in August. At Juneau in Southern Alaska the corresponding figures are 2.4 in January and 8.5 in July. The average transport of water-vapour from the Pacific coast is evidently quite small compared with that from the Gulf of Mexico.

(13) From the Arctic Ocean and the Behring Sea the amount of water-vapour entering the continent is very small at all seasons. On the Alaskan shores of the Behring Sea the amount is not negligible, particularly in summer. On the Arctic coast of Canada in winter the amount carried in from the Beaufort Sea is so small that difficulty of measurement under the low temperatures of that season has prevented accumulation of trustworthy figures. Cold air-masses from the Beaufort Sea passing up the Mackenzie Valley in midwinter commonly have temperatures about one metre above the ground of only 24°C . degrees above absolute zero or about 20 to 25°F . degrees below the Fahrenheit zero. At 240° absolute only 17 parts of water-vapour will saturate 100,000 parts of dry air. We may, therefore, consider that such cold air adds nothing to the vapour over the continent. On the contrary, after any slight warming on the continent it will absorb moisture from the surface of the soil.

(14) Air-masses from the Pacific may enter the Mackenzie Valley by the Beaufort sea-coast and carry small amounts of moisture into Mackenzie, Yukon, and Franklin. In July the average temperature of the southern portion of our polar and arctic territories in northeastern Canada is less than 28°C . above absolute zero (about 40 to 45°F .) and at this temperature can carry about 6 parts of water-vapour to 1000 parts of dry air at saturation. Of course, such air takes up moisture from the continent as soon as warming commences but its initial transport of water-vapour still remains over Canada during the sojourn over the continent. Moreover, after warming such masses can pick up further moisture from Hudson Bay. In summer, therefore, arctic transport of water-vapour cannot be neglected as a source of moisture.

(15) By way of Hudson Strait and Labrador polar Atlantic or arctic Atlantic air-masses sometimes enter upon the continent although the frequency of such a movement is of a small order. The water-content of Atlantic air in high latitudes may be sampled by taking the average of the readings at Grimsey in Iceland for the period 1873 to 1920. These give 2.7 grams per kilogram in January and 5.4 g/kg. in July and represent fairly well the maximum transport of water-vapour to be expected across the Labrador coast from air-masses moving westward towards Hudson Strait. Further north the observations from 1895 to 1930 at Angmagssalik on the east coast of Greenland indicate a mixing ratio of 1.7 g/kg. and 4.6 g/kg. in January and July respectively. Therefore, air-masses rounding the southern tip of Greenland and moving westward to the Labrador coast will contribute still less to the moisture of the North American continent.

(16) Continental air-masses moving off the Labrador coast to sea frequently display a returning movement on their southern margins which results in winds off the Atlantic upon the shore. Since these air-masses are warmed in their lower layers in winter by such travel, they will pick up further moisture from the Atlantic. Largely, however, on account of prevailing westerlies, the figures of normal vapour-pressure along our Atlantic coast reflect only a measure of the moisture carried seaward by off-continent winds.

(17) Along the southern reaches of the Atlantic seaboard tropical Atlantic air-masses from trade wind zones sometimes directly affect the coastal areas and, more rarely, our Atlantic provinces and Newfoundland. The mixing ratios for January and August average at Nassau in the Bahamas 13 and 18 per 1000 approximately. Since at Nassau the prevailing winds are northeast in winter and southeast in summer, we have here a good approximation to the average vapour-transport from the tropical Atlantic.

(18) Along the western coast of Mexico tropical Pacific airmasses contribute greatly to the average mixing-ratio, since west and southwest winds account for 57% of all winds in June and 46% in July. In the winter months these winds have a frequency of 20% to 30%. These figures are for Mazatlán and the water-vapour in January averages 11.5 g/kg., in June 17.7 g/kg., and in July 18.9 g/kg.

(19) In the foregoing paragraphs the relative importance of the various sources supplying water-vapour to the continent to replace the water continuously flowing away to the sea by lake and stream has been fairly well indicated, according to the average vapour in the air at coastal observing stations. It is true that the observations on which they are based were made approximately at sea-level and give no figures for upper levels in the atmosphere. While the climatology of the upper levels of the atmosphere is yet scarcely more than begun, there are enough data to indicate roughly that at much higher levels than the surface tropical airmasses carry water-vapour much exceeding that carried at corresponding levels by northern airmasses. Within those levels where thermodynamical cooling precipitates rain and snow upon the continent, by far the greatest part of the water-vapour is obviously transported from the tropical latitudes of ocean.

(20) Of the mountainous regions of the continent, the most important, from the point of view of those dwelling upon the Great Plains, is the Cordilleran system. In British Columbia the prevailing winds are east and southeast both in the interior and on the coast, except during the summer dry season when on the outer coast of Vancouver Island northwest winds prevail. On the Pacific coast of the United States we find at Seattle that east, northeast, and southeast winds have a percentage frequency of 49% in January against 11% for west, northwest, and southwest winds. Further south at San Francisco, east, northeast, and southeast winds account for 29% of all winds, while west, northwest, and southwest account for 40% in January, while Portland averages 38% for easterlies and 30% for westerlies. Therefore it seems that in winter there is a compensation for the prevailing easterlies of the Canadian Cordillerans. This compensation commences not far from Portland, Oregon, south of which there is a prevalence of westerlies. Far south at San Diego easterlies have a frequency of 34% and westerlies of 42%.

(21) In winter, the rainy season of the British Columbian coast, the cold air of the Cordilleran valleys is moving from east and southeast, or to seaward, while the moist air of the Pacific climbs up the slope of the cold air and moves inland over the mountains. The lower layers of continental air, therefore, approximate to cold domes of subsiding air, viewed from the top, although broken at the bottom by configurations forced by the contours of the mountainous region. To seaward when rain is falling on the coast, the dome of dense continental air presents a frontal surface to the upgliding and so cooling Pacific air. Not much moisture, therefore, is left in the Pacific air after it has passed the coast range, since the greater part of the available moisture has been precipitated.

(22) The rain-process demands that the less dense Pacific air shall ascend the slope formed by the barrier of subsiding dense Cordilleran air, and rise sufficiently high to cool below the condensation point with sufficient convergence of moist air to this region to provide continuously falling rain. The process of rising and cooling must cease when the Pacific air has cooled and dried to the point where it is in equilibrium with its environment at its new level. Having reached this level, it has no buoyancy to rise higher. Equally true, however, is the consideration that it cannot now descend. For if it descends ever so short a distance, it will gain heat by compression and so will be forced to ascend again to its former level. For this reason Pacific air, having passed the Cordilleran region cannot descend into the dense, dry, cold air of the prairies but must continue to ride aloft or even ascend still higher. The simple idea, so often encountered in text-books, pictures the Pacific air as ascending the mountains, cooling, and forming rain by simple orographical ascent, and then descending the eastern face of the Rockies down upon the plains, gaining heat by the descent. This descent would be perfectly simple if there were a vacuum on the prairies, but when the prairies are already occupied by polar air which is denser than the Pacific air coming over the mountain tops, how do the school text-books get the Pacific air down upon the prairies?

(23) Before Pacific air from the higher levels can descend to the plains, the lower layers of polar air to the east of the Rockies must be removed. Removal towards the east can be accelerated by cyclonic development within the continental area. Thus, a pronounced wave of low pressure passing along the eastern margin of the plains air mass (for instance from Colorado to

the Mississippi valley and thence to the Great Lakes and the St. Lawrence) will hasten the movement of air over the prairies toward the south and east. When this happens simultaneously with continued subsidence of the Cordilleran valley air, the occluded Pacific air may appear in the rear of the eastward moving plains air. At any rate, movement of air from the mountain-passes out on to the plains of Alberta is observed while at the same time southeasterly winds may continue in western British Columbia. Aerological data from aeroplane soundings in this region are lacking so that explanation of the actual mechanism of these chinook winds must await the time when such data have been procured. Dryness of the winds over southern Alberta is, however, definitely observed at the surface.

(24) Along the Pacific coast of the United States rain does not usually begin with an easterly wind as in British Columbia and Alaska but generally with westerly winds. Therefore, there is evidence to support the idea of simple orographical rains along that coast and the direct passage of air from the Pacific up the mountain slopes. Even in this case the air having passed above the mountains cannot descend to the plains unless the plains air is moving eastward. If there is no such movement on the plains, the Pacific air must remain occluded above the plains with only such subsidence as will compensate for a rate of rise on the Pacific face of the mountains which was greater than for the slope which a Pacific warm frontal surface would have displayed had the mountains been absent but the temperature and moisture-content of the coastal air had remained as observed.

(25) Actual analyses of many rainy periods on the Californian coast, however, indicate that much rain is caused by Pacific maritime air rising off the southern reaches of the coast and appearing as occluded air above polar Pacific air along the northern reaches of the U.S.A. coast. It appears, therefore, that much of the transfer of Pacific air across the mountains results in an upper sheet over the plains to the east of the Rocky Mountains which carries comparatively little water-vapour to the continent. When no frontal barrier to the progress of Pacific air exists, the situation is somewhat different. There have been several winters during the period of observation in western Canada which have been extraordinarily mild. During these abnormally mild months there are quite long intervals without distinct outbreaks of polar air moving up the Mackenzie valley to the wheat region. Pacific air then appears both on the coast and on the prairies while frontal surfaces are largely those between Pacific air from the Behring Sea region and Pacific air which has been modified in somewhat lower latitudes. The frontal surfaces, while not so oriented that they are normal to the mountainous coast, approach this condition. Both airmasses can cross the mountains so that one is to the south of the other. The frontal discontinuity then appears on the plains running west to east or northwest to southeast. The motion is then for either mass solely one of momentum from Pacific to prairie so far as crossing the mountains is concerned. During such periods westerly winds, only, are recorded in Alberta and Saskatchewan, and the temperatures are very high for the winter season. It is worthy of note that this type of atmospheric circulation, while the only one which conforms closely to the usual description of the chinook mechanism, appears never to be called a "chinook" by those who dwell east of the Rockies. Since occasionally there is enough difference in the characteristics of these two Pacific masses, so that the southerly one ascends the frontal surface of the northern one to an extent which brings a very little rain or at least much cloud over a portion of Alberta, the extreme dryness associated with the usual description of a chinook is not in evidence.

(26) We have, then, as one measure of the alpinity of a western climate, the difference in water-vapour content between mountain and adjoining coastal stations. Thus, at San Francisco, San Luis Obispo, Red Bluffs, San Diego, and Eureka the water-vapour in January averages 5 or 6 g/kg. of dry air while at Independence and Winnemucca and Flagstaff it falls to 3 or 4 g/kg. and at Boise City, Las Vegas, Modena, Salt Lake City to ratios between 2 and 3 g/kg. The eastern slopes of the plateau region average less than 2 per 1000 in January. In summer, on the other hand, the water-vapour is large on the plains and along the eastern slope of the plateau but continues low at high elevations and on the western slopes of the mountainous coastal belt. Thus, at the first five places mentioned above in July the mixing-ratio is about 9 per 1000 while on the plateau it varies much with locality from 5 to 9. On the plains we find 10 to 16 per 1000 in July. This reversal of the situation accompanies the setting in of a quasi-monsoonal régime which brings prevalent southeasterly winds and much water-vapour from the Gulf of Mexico to the Great Plains.

CHAPTER II

Manitoba's Climate compared with other Climates on the North American Continent

(27) If we can find a method of reducing the continentality, maritimality and alpinity of the North American climates by a common measure, we can graphically depict these relative characteristics upon a map and so see where Manitoba's climate fits into the whole view. This can be done if we make use of the ratio expressed below. Let V be the average amplitude of temperature variation, so that V_a = difference between the mean temperatures of the warmest and coldest months of the year (generally the difference between the mean of January and July), V_w = average daily amplitude of temperature in the warmest month, V_c = average daily amplitude of temperature in the coldest month, W_w = average weight of water-vapour to 1 kg. of dry-air in the warmest month, W_c = average weight of water-vapour to 1 kg. of air in the coldest month. Then continentality will vary with the value of the fraction

$$\frac{V_a V_w V_c}{W_w W_c}$$

We measure temperature by degrees centigrade, and get for every observational point a value which is small upon the coasts, larger in the mountains, and largest in mid-continent. A few examples follow.

(28) At Key West which should naturally be taken as an example of a point with very low continentality, we find the difference between the mean temperatures of January and July to be 8.0 C.; the mean daily range of January and July to be respectively 5.3 C. and 5.7 C. The mixing-weights are 12.5 and 20.6, using the values of 81% and 81.5% for relative humidity and 293.7T and 301.8T as the average temperatures of January and July. The value of the fraction for Key West

$$\frac{8.0 \times 5.3 \times 5.7}{12.5 \times 20.6} = 0.94$$

Similarly for Winnipeg, we have 38.5 for the annual amplitude but 10.8 and 13.2 for the daily range in January and July with mixing-weights of 0.5 and 12.9. The value of the fraction for Winnipeg is then

$$\frac{38.5 \times 10.8 \times 13.2}{0.5 \times 12.9} = 536.9$$

When these fractions are written upon a map of the continent at the points to which they refer, they will have no specific meaning but it is at once evident that there are very large variations which must be expressed in terms of some constant. The most natural constant to take is the average value of all the fractions. Differentiating these by lines which pass through equal values of the fractions and superimposing a grid of 300 equiareal squares upon the map, we can find the average value for each square. Totalling the values for the squares and dividing by their number, we get as the average value for the continent 879.6, from Mexico City on the south to Craig Harbour on Ellesmere Island in the Arctic regions and between the Atlantic and Pacific Oceans. We find Winnipeg is below average in respect to continentality. Dividing its value by the average, we can express its continentality by 60.1%, while for Key West we obtain 0.1%.

(29) Plotting all percentages upon a map, we find exceedingly large numbers in north-western Canada while on the lower Great Plains and in the Mississippi valley the numbers increase very slowly. If the figures are graphically divided by lines at equal intervals of percentage, the lines will be illegibly crowded in the northern interior and there will be no lines upon a great part of the southern interior. Some method of discovering the rate of increase of continentality must be found. Considering any pair of stations and producing the line joining them till it meets the nearest coast, if we call D_s the increase of distance from the coast and D_c the increase in continentality-percentage, we find that all such measurements have a general similarity which can be expressed by

$$D_c = k s D_s$$

Integrating, we have then the statement that the continentality varies as the square of the distance from the ocean.

(30) The factor of proportionality, k , has not the same value when one measures from the Pacific coast as when the distance is taken from the Gulf of Mexico. Also k differs along the Atlantic coast. All these differences are evidently due to the Cordilleran and Appalachian mountain systems. If we, therefore, choose k to suit the Gulf of Mexico and differentiate our map on this basis throughout, we shall obtain a graphical summary of the variations of k which will be useful in determining the relative importance of the roles played by the various ocean surfaces and mountain chains. Proceeding on this plan, we obtain the map of continentality printed herewith. The ratios of 1% continentality are joined by a continuous line, then the ratios of 2%, 4%, 8%, 16% and so on, each successive line representing a doubling of continentality. We now get fairly even spacing of these lines; which shows that actually three times the distance from the Gulf of Mexico is associated with nine times the continentality, four times the distance with sixteen times the continentality and so on. We readily find exceptions to this rule by noting those areas where spacing of the isocontinentals departs widely from uniformity.

(31) The effect of the tropical Atlantic waters is seen to be very large while the Great Lakes of the St. Lawrence evidently have an ancillary role in spreading the maritimal effect of airmasses from the Gulf of Mexico at a rate somewhat faster than that computed to be the normal rate. The contrary effect of the Appalachians and of that portion of the Canadian Shield north of the Great Lakes is also quite evident. On the western portion of the continent the effect of the Pacific is almost totally nullified by the very high St. Elias mountain range, of which Mt. Logan reaches 19,850 feet, while King, Lucania, Steele, St. Elias, Vancouver and Wood peaks are 15,000 to 18,000 feet or more above sea. In southern British Columbia after the first abnormal increase of the proportionality factor at the Coast Range it flattens considerably. From the gradients east of the Rockies to lower Manitoba it appears that the upper Peace River country and the adjoining Athabasca region as far north and east as Athabasca Landing, southern Alberta from Edmonton eastward to Vegreville and thence south to Empress, thence in Saskatchewan eastward to Swift Current and Moose Jaw and south to the International Boundary are all dominated by Pacific influence when not under the influence of Arctic airmasses. The line of average continentality cuts through the Great Lakes of Manitoba and through the middle of the region at present cultivated in Saskatchewan.

(32) The general contours of continentality suggest that the transport of water-vapour from the Gulf of Mexico by way of the basin of the Mississippi reaches towards eastern Manitoba and the Red River valley much more frequently than to Saskatchewan. In northern Manitoba and northern Saskatchewan the continentality is very high and not greatly exceeded anywhere except in the Northwest Territories. This is due to the very great influence of Arctic airmasses west of Hudson Bay, and this body of water appears to have much less maritimal effect than might have been expected.

(33) If we try to correlate the isocontinentals with known distribution of staple crops and forests, we shall soon find that this map can serve only as groundwork for a proper delimitation of regional climates. Superimposed upon it we must lay other maps with seasonal characteristics. But one can see that the present limit of agriculture does not greatly differ from the line of 128%. In Saskatchewan the present limit lies a little to the north of 128% while in Alberta it lies a little south. Along the north of the St. Lawrence it is considerably south. The northern limit of the northern forest appears to agree fairly well with 256% in those regions where the soils are not too thin for growth. The northern forest, as described in the Canada Year Book, is succeeded in the north by tree growth in narrow strips along the waterways. Presumably the lands immediately along the waterways may be regarded as resembling irrigated lands.

(34) We may say then that our discussion of continentality shows little hope of materially extending agriculture in Manitoba beyond latitude 55 and that the wheatlands have probably reached already their furthest limit in the vicinity of the lower Saskatchewan River. Below the line of average continentality there is a smaller territory than there is below the line in Saskatchewan which in turn has less favorable territory than Alberta and British Columbia. However, we should note that much of the territory of less than 64% continentality in Alberta and Saskatchewan has insufficient rain for crops and that full advantage of the comparatively low continentality can be taken only when irrigation is practised. Therefore, we may modify our conclusion to say that the area of Manitoba which could be improved by irrigation must be considerably smaller than in the other western provinces.

(35) In devising the formula for continentality use was made of the amplitude of temperature variation only and not of the temperature itself. With high temperatures high continentality should be associated with desert conditions but with low temperatures high continentality should be associated with tundra. This last may be described with approximate accuracy as low-temperature-desert. Between these extremes moderate temperatures and high continentality can be quite favorable for health and comfort and may be much preferred by some people to any other combination. For some types of manufacturing such a type of climate may have decided advantages. For growth of crops, however, where events which may be eminently favorable at one stage of plant development can be positively detrimental at another, the variations of the weather throughout the season of growth are of paramount importance. As a first step towards investigating the seasonal variations in Manitoba, we may enquire how far the warmest and coldest months depart from average type over a period of years.

CHAPTER III

Temperature Variations in Manitoba

(36) In diagram 2 the number of Januaries at Winnipeg which have had mean temperatures within the indicated classes have been counted. Each vertical array shows the number of cases of Januaries whose mean temperature fell within a class two Fahrenheit degrees wide. With normal distribution of events we should expect to find the largest number of cases grouped about the mean value of all. Although the average temperature of January is 2.7 below zero Fahrenheit, there are only four Januaries out of sixty-four which fall in the class "minus one to minus three." Therefore, an "average" January is likely to happen only once in sixteen years. There is clearly an abnormal distribution of events here and we see that the largest group which appear to be symmetrically grouped about a mean value are those which arrange themselves about the value seven below zero. There is another group whose centre of probability is two above zero and still a third group (very askew) of which nine fall in the class five to seven degrees above zero with seven others ranging from seven to eleven above zero.

(37) The first and largest group are Januaries dominated to a very large extent by airmasses of polar origin drifting southeastward over the continent with very little modification of the temperatures and moisture-content of the densest layers. The intense outward radiation from frozen ground and snowy surfaces through very dry air keeps the temperatures very low during travel across northern Saskatchewan and northern Manitoba. The second group of Januaries were those during which considerable relief from bitter cold-waves was experienced. Airmasses travelling westward from the Pacific, from mid-continent and the Behring Sea by way of the Mackenzie district, all of polar or arctic origin but considerably modified near the surface of the earth, invaded Manitoba sufficiently to compensate for short periods with intense arctic continental cold. Slow drift westward of returning continental air from the eastern portion of the continent may also be seen to have contributed to comparative mildness on some occasions. The third group, while not a homogeneous one, corresponds to Januaries which were also milder than usual further west but not generally as mild as at Winnipeg. Arctic continental cold in these Januaries was either largely confined to the far northwest or to the far northeast or both. Airmasses from midcontinent with much northward returning air characterized by southerly winds in the Missouri valley brought about a régime dominated by drift of air from west and southwest. Since most of the midcontinental air during these Januaries was originally "polar Pacific" or arctic Pacific air crossing into the continent in fairly low latitudes, we may characterize these Januaries as "Pacific Januaries."

(38) At Winnipeg we have, therefore, "Arctic" Januaries with mean temperatures of -17°F. to -2°F. but averaging about -7°F. and occurring about 58 years in a century. We have also "Pacific" Januaries whose mean temperatures range from 4°F. to 12°F. but average 7°F. and occur about 24 years in a century. The remaining 18% of all Januaries have a range of mean temperatures difficult to compute because of their hybrid character but apparently mostly frequently having mean temperatures between one and three degrees above zero Fahrenheit. An "average" January is, therefore, the most unlikely of all Januaries to occur at Winnipeg but may happen about 6 years in a century and will have a mean temperature about three degrees below zero Fahrenheit.

(39) At Minnedosa in southwestern Manitoba we have only 54 Januaries whose temperatures are available. Again we see three types, that centring about -9°F. and that centring about $+7^{\circ}\text{F.}$ with a third intermediate type having mean temperatures most often immediately above or immediately below zero. The intermediate group is more numerous at Minnedosa and averages a little lower than at Winnipeg.

(40) Referring to the diagrams for July, we see that there is a much more symmetrical grouping than in January. The average of all Julys at Winnipeg is slightly less than 67°F. and Julys with means between 66° and 68° are seen to be the most numerous, while at Minnedosa the average and the mode also nearly coincide. At Winnipeg the number of Julys below the modal class is nearly the same as the number above. At Minnedosa there are 25 Julys cooler than the modal class and only 13 warmer. The spread of temperature is considerably greater at Minnedosa, Julys ranging between means of 56° and 74° with the greater number falling between 60° and 68° . At Winnipeg the spread is from 60° to 76° with the greatest number falling between 64° and 70° .

(41) At The Pas July has been known by its temperature for only 25 years and the diagram is scarcely dependable for such a short period. There is an indication of two different modes, one at 63° and another at 69° , the latter with a frequency of about one year in eight. This upper mode is made apparent by the fact that in the 25 years no July with a temperature between 66° and 68° has occurred at The Pas. It will take a long record in future to determine whether the gap in the frequency polygon has any real significance.

(42) Turning now to the pages where daily maximum and minimum temperatures have been analyzed according to the frequency of their occurrence during the period 1906-1936, we find that these have been arranged in classes of eighteen degrees width. The most frequently recurring temperature is indicated by red type in each month. At Winnipeg, Sprague, and Morden, so far as daily maxima are concerned, there is much similarity between December, January, and February, since the most frequently recurring daily highest temperatures lie in the class 5°F. to 23°F. At Minnedosa, Birtle, Russell, Dauphin in the west, and at Norway House in the north, January and February afternoons are more frequently colder than in December while January is quite definitely the coldest month. March and November show a decided similarity except at Norway House where March afternoons are generally somewhat colder than November afternoons. April and October afternoons are very similar while May and September make another pair. July is evidently the month with most frequently recurring hot days but the distinction between July and August is not very great. The spread of temperatures is seen to be greater in winter than in summer.

(43) From the point of view of daily minima the situation is very similar except that a curve connecting all the highest frequencies throughout the year at any of these stations is distinctly flatter in the summer half-year than the curve of highest frequencies for the maxima. Or, in other words, July nights do not show so much more warmth over those of June and August as might have been expected from the peak of daytime warmth in that month. Frosty or near-frosty nights (with minima of 23° to 41°) are the most frequently occurring class in April, May, and October at Winnipeg, Morden, and Dauphin but at other points September also has most nights in this class. Sprague, in the extreme southeastern corner of the province, has a greater number of cool nights in summer than might have been expected from its southerly position.

(44) Before leaving this preliminary examination of temperatures, we should look at the maps and tables showing the dates of first and last frost and the average frost-free period. Along the Gulf of Mexico there are over 240 days frost-free and this period diminishes as we go north along the Great Plains to 120 to 150 days over most of the northern middle-west states. In northern Montana and northern North Dakota we find 90 to 120 days. In the Red River valley of Manitoba the average date of last frost is about the 145th day of the year while the first frost is expected about the 260th day. This gives us a frost-free period of about 115 days, varying from 96 at Graysville to 118 at Morden. Westward over the wheat region the frost-free period is generally shorter. Between Turtle Mountain and Souris and also from Emerson to Turtle Mountain there is a region with 100 to 115 days or more continuously free from frost on the average, but generally west of the Red River and south of Lake Manitoba the frost-free period is less than 100 days. Towards Riding Mountain and the slopes of the Moose Mountain ridge draining to the Souris River the period diminishes to less than 80 days. East of Duck

Mountain the station at Dauphin has for many years reported a frost-free period longer than might have been expected in that region. Since there is no other temperature station that can be used as a check against local variation, we assume that the 109 days recorded there is true only a short distance from Lake Dauphin and then only on slopes with uninterrupted air-drainage. Local depressions where still cold air can accumulate on clear mornings are less likely to be frost-free, nor are places immediately along the lakeshore likely to be so favorable.

(45) Between Winnipeg and Portage la Prairie and along slopes draining towards the southern end of Lake Manitoba or Lake Winnipeg 100 to 109 days may be continuously frost-free on the average. Along the east shore of Lake Winnipeg there may be 85 to 90 days but eastward the period is probably much less although no data exist east of Berens River. At The Pas, Cumberland House, and Flin Flon short records indicate 95 to 109 days but these are probably quite local where lake influence and general shelter are prominent. The countryside away from the lakes probably suffers much more from frost, especially low-lying ground.

(46) While Kenora, Ont., and Warroad and Roseau south of the U.S.A. boundary, show 95 to 120 days free of frost, the station at Sprague has for many years reported a very short period, averaging only 62 days. Unfortunately, there is no other station between Sprague and Emerson so that we are unable to say how far west and north this region of high frequency of frost extends. If it were not for the fact that periods as short as 70 days occur in the adjoining region of Minnesota, I should doubt the accuracy of the readings at Sprague. Thermometer readings from Marchand and Birch River over a period of years should be useful to clarify our knowledge of frost in the area between the Red River and the Lake of the Woods and between the Winnipeg and Roseau Rivers. In the meantime, we are assuming that the Whitemouth River basin has 65 to 90 days frost-free.

(47) While ordinarily the occurrences of minima of 32° to 33° Fahr. in the thermometer screen (about 4 feet above ground) are regarded as evidences of temperatures at least one or two degrees lower at the surface of the ground, and regarded as sufficient criteria of the frostiness of a region, exception has generally been taken on the prairies to using such temperatures as significant for wheat-growing. A temperature of 29° to 30°F. in the screen is said to denote a killing frost. Conforming to this view, we give a map and table showing the incidence of late and early frosts of this severity. As might have been expected, the general contours are not greatly changed, but the period is lengthened by 25 to 30 days for the most part in the southern regions. The few stations around the north of the Great Lakes of Manitoba indicate a smaller improvement in period, 20 days or less. This is to be expected since dry, cold air masses advance from that region and mostly when severe enough to cause a light frost of 32°F. in the southern districts, such masses will produce frosts of 29°F. or lower north of the lakes.

CHAPTER IV

The Precipitation of Manitoba

(48) The precipitation of Manitoba (rain and water-equivalent of snow) is about 19 inches or about 2100 tons per acre in the southeastern district; about 16 inches or 1800 tons per acre in the southwest; about 21 inches or 2375 tons per acre in the interlake district and 13 to 16 inches in the far north. There are local peaks according to the observations but since these are not all for the same period and some periods are rather short, not much emphasis should be placed upon them. Probably the tongue of 20 inches or more extending from immediately east of Winnipeg to a broad base of 24 or 25 inches on the Lake of the Woods has real significance. The peak of 24 inches at Grand Rapids in the interlake region is based upon a very short record but looks possible; 20 inches or more on Lake Manitoba stands upon a better basis of observation. The drop to 15 inches across Lake Winnipeg, both at the south end and over the upper reaches of the lake, also stands on a period of considerable length. About 20 stations across the border in the U.S.A. and about 20 in Saskatchewan or Ontario have been utilized to carry the isohyets over the marginal territories, east, west, and south.

(49) In April there is generally only about 6% of the annual precipitation but the percentage of the annual total occurring in May is about 10 or 11% in the southeast, and far southwest, 7 to 9% in the middle south and the interlake region but only 1 to 7% in the far north.

In June about 16% falls in the southeast and 16 to 21% in the southwest, while over the interlake region the percentage rises to 15 or 20%. The far north shows a large increase with 13 to 17%. In July percentages fall off sharply in the interlake region, increase greatly in the far northwest, and remain quite high in parts of the southwest.

(50) The percentage of the annual precipitation which is snowfall averages about 20 to 25% over most of the southeast and southwest but over the interlake region, the Duck Mts. and Porcupine forests, and the far north, rises to 30% in some places. Particularly high is the percentage due to snow from the Great Lakes to Hudson Bay, reaching 39½% at the Bay. Not all of these percentages refer to the same period of the year, of course, since snowfall still occurs in the colder regions after the precipitation of the south has changed to the rains of spring.

(51) The annual precipitation increases sharply in April since only 3 to 5% of the annual total may be expected in March. The peak occurs on the average towards the end of June but the slackening in July is not very rapid. In September the Red River valley and the northern districts hold up quite well but elsewhere the drop in precipitation is very noticeable. Another sharp drop comes late in October or early in November with the tendency to precipitation rather higher in the north in November than in the south. The winter-minimum of precipitation then sets in to remain till April. February is the driest month in the south but March is driest in parts of the interlake district and the lower Saskatchewan River region.

(52) The coincidence of the frost-free period with the period of maximum precipitation is of great importance to agriculture. The comparative dryness of March and early April is also advantageous since it allows the operations incidental to sowing seed to be completed before the rainy season is well started. A very mild, early season accompanied by rain makes spring sowing very difficult in all parts of the continent since the ground is too soft to allow operations upon it. It has been stated that a sufficiently dry March will allow implements to be used while the sub-soil is still frozen and firm very close to the surface. No data exist concerning sub-soil temperatures so that no attention can be devoted to this point but, on the other hand, there are notes regarding the time of sowing on record which show that seeding has been delayed till the first week in May in the southern districts by mild, wet weather in March and April.

(53) While the short frost-free period is sufficient reason for as early seeding as possible, the coming or failure of midsummer rains is the most important single feature of the weather of the year. While not so erratic as the summer rains of the central prairies, the midseason precipitation of Manitoba is far from dependable. Since the peak of summer heat occurs in July, if the peak of raininess does not keep pace with it agriculture naturally suffers. Regarding the variations of summer raininess in past years, the tables giving the history of the seasons at all places with fairly long record will be found of general interest.

(54) April 1st to July 31st has been taken as the season of growth and for this period in each year the total precipitation has been tabulated. Also, since there are many who hold to the view that in some parts of the western provinces there is actual storage of water in the soil from August to the surface-freeze in early winter which is utilizable by spring-sown plants, the precipitation from August 1st to October 31st has also been tabulated. To complete the twelve months, we have the precipitation from November 1st to March 31st. The writer is not at all sure that these dates are particularly significant. Since there is no water-table over much of the prairies and evaporation and stream-flow continue to carry away surface-water at a rapid rate until the surface-freeze occurs in the autumn, it seems doubtful that the rains of August and September contribute much to the moisture of the layers near the surface in the following spring. Moisture near the surface in October is undoubtedly frozen, early or late according to the weather of any given year and it seems reasonable to suppose that this may be freed in a dry spring at a time when it will be available for the roots of seedlings. Against this may be offset the occurrence of heavy rains in early spring. Falling on a frozen soil with little or no opportunity for penetration of the sub-soil, such rains must be largely run-off with freshets in creeks and rivers and flooding of lowlands.

(55) The accompanying factors in respect to storage and utilization of surface-water differ so much from year to year and place to place that no simple rule for the division of the annual precipitation can be found. However, the coincidence of the peaks of heat and precipitation in

this region certainly make the amount from April to July of great significance. Major Strange of Winnipeg contributed financially to a tabulation of figures on the basis named for the other seasons and, therefore, we are able to utilize this tabulation here. To prepare another tabulation on the basis of weekly temperatures from year to year appears to be a sounder method. Thus, the precipitation preceding by 30 days the winter "freeze-up" might well have been taken separately but this would entail many weeks of search and compilation from the original records which cannot be undertaken at present.

(56) As a guide to the variation of the precipitation of the growing season, the difference from the average for each summer was tabulated for several points with long record. The differences were squared and the root of the average of the squared differences found. These standard deviations are tabulated below.

No. of Years Record	Place	Average of Growing Season	Standard Deviation	% of Average
62	Winnipeg.....	9.62 inches	3.10 inches	32
46	Oakbank.....	9.61 "	2.92 "	30
51	Brandon.....	8.82 "	3.23 "	36
30	Dauphin.....	7.54 "	2.98 "	40
32	Cypress River.....	8.19 "	2.87 "	35
20	Deloraine.....	8.96 "	4.20 "	46
24	Birtle.....	7.56 "	3.55 "	47
53	Minnedosa.....	8.49 "	2.34 "	27
51	Rapid City.....	8.19 "	2.79 "	34
43	Russell.....	7.67 "	2.37 "	31
42	Swan Lake.....	9.40 "	3.15 "	33
51	Treesbank.....	8.76 "	2.57 "	29
27	Souris.....	8.37 "	2.89 "	34
51	Morden.....	8.53 "	3.55 "	41
23	Ninette.....	8.17 "	3.20 "	39
51	Treherne.....	9.39 "	3.38 "	36
32	Virden.....	6.73 "	3.29 "	49
25	Oakdale Park.....	10.37 "	4.36 "	41
31	Pierson.....	7.40 "	3.75 "	50
20	Sprague.....	8.74 "	3.10 "	35
34	Portage la Prairie.....	9.29 "	2.93 "	32
20	Moose Horn Bay.....	7.83 "	2.29 "	29
25	The Pas.....	6.42 "	2.34 "	36
39	Norway House.....	5.35 "	2.66 "	50
21	Pinawa.....	6.26 "	2.64 "	42
45	Berens River.....	6.55 "	2.41 "	37
19	Swan River.....	8.17 "	2.74 "	37
47	Grenfell (Sask.).....	8.62 "	2.72 "	37

If these standard deviations are set down upon a map, we find that the precipitation of the growing season is as likely to be 30% above average as 30% below average in the interlake region. The line enclosing deviations of 30% begins a few miles east of Winnipeg, runs north to Winnipeg Beach, thence to Arborg, Hodgson, and Gypsumville, thence south but east of Riding Mountain Forest to Minnedosa, passes east of Brandon, south to Morton Forest. Thence it goes north to Carberry Forest and Gladstone but north of Portage la Prairie and east to Winnipeg. In excess of 40% there are Pinawa and Morden, each isolated. But the region including Birtle, Virden, and Pierson shows 47% to 50% while Dauphin and Deloraine show 40%. Therefore, from Riding Mountain south but west of the Souris River we have the region of greatest undependability of precipitation where summer rainfall is as likely to be only one half the normal amount as one and one half the normal amount. In the north Swan River, The Pas, and Berens River have a standard deviation of 36% and 37% while Norway House has 50%.

(57) To minimize the probable error of the deviation due to length and lack of simultaneity of period, only the longest records have been utilized. Pinawa record is short and was used because no long record was available in that district. Not too much weight should be given to

these figures but they have some value when considered broadly. It is interesting to see that the forests of the south seem to fall within a region of comparatively high dependability of rainfall. Such dependability may be assumed to have given the trees a chance to get a foothold originally and to have allowed the trees to maintain sufficient annual growth since that time to avoid extinction by droughts.

(58) As a matter of some interest a short table is presented for a few points showing extremely wet and extremely dry years. The driest five successive years seem to have been those from 1886 to 1890. The driest five successive crop-seasons were 1893-1897, 1914-1918, or 1917-1921, and 1932-1936. The choice depends upon district and length of period to some extent. The driest single year seems without doubt to have been 1886 although not very many records go back that far. The driest single crop-season varies with locality but 1900, 1913, 1917, 1925, 1934, and 1897 appear to have been generally bad.

(59) The Winnipeg record shows that there was an extraordinarily wet period in Manitoba from 1876 to 1880, the like of which has not recurred. The records at Pembina, Garrison, Mandan, and Abercrombie show that this wet period was experienced to some extent in the Dakotas while evidence of a wet period either simultaneously or in the years immediately following is found in the Nebraska records. The records from Montana show little evidence of it. However, there was a wet period in the northeastern portion of North America about that time, so that we may say that Manitoba was on the western margin of a wide area of abnormally high precipitation in the late 'seventies and 1880. There is, of course, no valid argument that can be adduced against the recurrence of such a wet period at some time in the future.

(60) Having considered the variability of the rainfall by amounts measured for the year and the growth-season, we may devote some attention to the frequency of rainy days without regard to amount. In some situations a rapid and heavy downpour may be largely surface run-off to streams with surprisingly little percolation to soil. A dust consisting largely of clay exhibits a tendency to form a skid-surface when attacked by the first onset of a heavy rain while sandy loams allow greater percolation even after protracted drought. Slope of the land also contributes to the surface run-off factor. The effectiveness of a given amount of precipitation for a day, a month, or a season is, therefore, not easily judged. For a season there is no doubt frequent rainfalls, even though not heavy, contribute much more to steady and vigorous plant growth in an exceptionally continental climate than do a small number of heavy downpours which aggregate the same total of precipitated water. With this viewpoint in mind the precipitation of every day for 30 years at Winnipeg and Minnedosa has been carefully sorted according to the following scheme. For each year from April to August, inclusive, the total number of rainy days has been counted. These have been sorted into cases of two successive days with measurable rain, three successive days with rain, and so on to a group of five or more days each with measurable rain. Against these rainy days have been set cases of two or three successive days without measurable rain, four or five successively dry days, six or seven, and so on to twenty-two or more dry days in sequence.

(61) It will be easily evident that one rainy day alone is by long odds the most likely event. Out of 153 days from April to August Winnipeg will likely have 64 days with rain but there are likely only 7 pairs of rainy days. The average number of triplets or better is 2.7, that is, 2 or 3 in a season, while for fours or better there is one chance in a season. Rain on five successive days has occurred at least once in twelve out of thirty years. The occurrence of successive days without rain is also shown for Winnipeg and it is seen that a dry spell of two or three days is most common but that a week of dry weather occurs once to four times a season. Three weeks without rain has happened in four years out of the thirty.

(62) At Minnedosa we have only 56 rainy days on the average during the April-August season, while not quite 7 cases of two days or better with rain occur on the average, and two or three of these may be cases of rain on three days or more, and one of four or more. Cases of five or more successive days with rain have occurred in 17 out of 31 years. On the other hand, two or three days of dry weather are most common but there were only 5 years out of the 31 which did not have at least one totally dry week. Three weeks of drought are seen to be very rarely encountered.

(63) It may be well to point out that under the heading "Successive Days with Measurable Rain" 2 means "2 days or more;" 3 means "3 days or more," and so on.

(64) Precipitation at Winnipeg and Minnedosa during the thirty years was counted daily for every month and assigned to one or other of the following compartments: (a) no precipitation (b) amount too small for measurement (c) $1/25$ of an inch (d) $1/5$ of an inch (e) $6/10$ of an inch (f) 1 inch (g) $1\frac{1}{2}$ inches (h) 2 inches or more. From the total number of cases in each compartment a table of chances for and against a day with various amounts of precipitation in each month of the year has been computed. An example will make the use of the table clear: thus, in July at Winnipeg the chances of rain on any day are 35 against and 27 for. This may be simplified to nearly 4 to 3 or, in other words, in a week four days will likely have no rain but three days may have some rain even if the amount is too small to measure. That the rain will be 0.04 or more (that is about four tons per acre or more) the chance is seven such days out of the month, while the other 24 will have no rain or less than 0.04. The chance of a rainfall of 0.20 inch (about 23 tons to the acre) is scarcely half as good. One day in the month with 0.60 inch (68 tons per acre) may be expected to occur but the chance of any greater amount is negligible. The accompanying diagram (4) will perhaps be more readily interpreted than the figures in the table itself. The chances of a day without precipitation are seen to be about 60% at Winnipeg except in June, July, November, and December when the chance is smaller and least in June at 52%. In Minnedosa the chance of a fine day is about 70% except in June, July and August but is smallest in June at 53%. The chance of a day with 0.04 inch or better is about 15% except in May to September when it is 20% or better and greatest in June, about 30%. The chance of 0.20 inch or better is about 10% in summer and 5% or less in winter. The chance of a heavy rain is about 2% to 3% in summer while the chance of a very heavy rain is small or negligible.

(65) The frequency of rainy days per month by amount and by wind-direction accompanying the showery weather will be of interest in clarifying our ideas of the weather. For this purpose we take stations where wind-direction is given by an anemometer in this region. These are Winnipeg, The Pas, Qu'Appelle, and Prince Albert, the last two in Saskatchewan. To fill the gap in western Manitoba the station at Minnedosa has been utilized. At this point there is no anemometer but the observer judges direction and speed by eye, night and morning. The evening estimate has been chosen as the prevailing wind of the day.

(66) In April northeast, east, southeast, and northwest winds seem most likely to be accompanied by rain which is heavy while south and west winds are not only infrequent but generally dry. In May northwest and southeast winds are the most frequent but the northwest winds are more frequently accompanied by rain. In the cases where rain occurs with a southeast wind however, it is more likely to be heavy than with a northwester. Northeasters, although not so frequent, are more likely to be accompanied by heavy rain. South, southwest, and west winds have little rain accompanying them.

(67) In June northwest and southeast are again the most frequent winds and have a wide spread of light to heavy rains accompanying them. Northeast and east winds are also fairly frequent and when they occur may have quite heavy rains. In July northwest and southeast winds are most frequent with the greatest spread from light to very heavy with easterly winds. In view of the heavy damage done by droughts in July (especially after light rainfall in June) it will be of interest to analyze the figures for Winnipeg more thoroughly. Totalling all occurrences of north winds we have 28 in the ten years from which the record was made. Of NE days we had 28, of E 14, of SE 67, of S 32, of SW 25, of W 31, and of NW 69, while 12 days were calm. In the ten years these should total 310 days instead of 306, but the remaining 4 days are spread over the table as fractions and indicated by an asterisk. These totals make evident that NW and SE winds are easily the most frequent. Of the 28 N days 8 had rain of some amount, making the percentage rainy to be 29%. Of the 28 NE days 13 were rainy or 46%. Treating all by the same method, we have the following result:

	N	NE	E	SE	S	SW	W	NW	CALM
No. of Days	28	28	14	67	32	25	31	69	12
% rainy . . .	29	46	64	61	34	52	52	16	25

From this we see that rain is most likely with an east or southeast wind in July at Winnipeg.

(68) Totalling and taking percentages for June at Winnipeg we have

	N	NE	E	SE	S	SW	W	NW	CALM
No. of Days	42	30	22	58	30	31	23	55	9
% rainy	33	50	45	57	47	52	43	44	33

SE and NW winds are again most frequent but the SE, SW, and NE are proportionately more rainy than other directions. For May similarly for ten years we have

	N	NE	E	SE	S	SW	W	NW	CALM
No. of Days	61	41	23	57	28	23	10	59	6
% rainy	21	41	57	37	43	30	50	32	17

In this month north winds have been most frequent while NW and SE show their usual prevalence. East and west are rainiest although for all easterly winds there are more frequent rains than for all westerly winds. Similar summaries may be made for other stations by anyone who is sufficiently interested. The question will be considered again in a later section.

(69) The amount of water-vapour carried in the air on the average has been computed for several points where observations of humidity are made. The months of June, July, and August for the years 1928 to 1937 (and also 1923 for some points) will be found analyzed in the accompanying tables. An example to make the use of the table clear follows. From the table for June at Winnipeg for 1937 we find in the first column the mean temperature at 7 hours Central Time to have been 54.1 Fahr. This is labelled " t_d " for "dry thermometer." In the third column in the same array we find under t_w the mean of the wet thermometer at the same hour. The difference of the two given under $t_d - t_w$ was 2.4 degrees, which indicates a relative humidity of 86%. Under W_s we find that air of that temperature will be saturated by 9.7 grams of water-vapour per kilogram of dry air. Since the relative humidity was 86% there were, therefore, $9.7 \times .86 = 8.3$ grams of water-vapour actually present for each 1000 grams of dry air. Similarly, going back along the same array, we can find the mean values for 19 hours. It will be seen that the water-vapour is higher at the evening observation than in the early morning in all cases. This happens generally because the air chills by radiation at night sufficiently to reduce the amount of vapour that can be carried. The excess over saturation is then deposited. After warming has taken place the relative humidity falls sufficiently to allow the air to absorb the vapour which was lost. The amount taken up is about on the average 1 or 2 parts per 1000 parts of dry air as may be seen from the averages of various years. A small portion of the vapour rises into higher-level circulation to form low clouds of fine weather.

(70) The most humid and most arid day in the month is also given. Thus, for June, 1937, the most humid day at Winnipeg was the 23rd with 13.2 grams per 1000 of dry air at 7 hours and 21.5 grams at 19 hours. The dew-point (or the temperature below which 21.5 grams would begin to condense as ground-fog) was 76 Fahr. Since the lowest temperature the next morning was 62 Fahr., there was evidently slight deposition of moisture if the same air mass remained over Winnipeg. Again for the most arid day, the 6th of June, we had 76 parts of water-vapour to 10,000 parts of dry air at 7 hours and 48 per 10,000 at 19 hours. The temperature was so low that an extremely slight amount was lost during the following night to the ground as dew.

(71) If we set down the average moisture in the air at 19 hours with the corresponding rainfall for the same month, we have the following table:

June	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Vapour at 19 h.....	9.4	9.9	10.0	10.6	12.6	10.9	9.3	8.6	9.2	9.2
Precipitation.....	3.58	1.37	2.55	1.13	2.91	0.97	4.15	4.15	2.41	2.32

We see that the wettest Junes are associated with the driest air while the driest June had the second wettest air, from which we may conclude that a high moisture-content of itself is not a guarantee of rain. Arranging the same data for Julys we have:

July	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937
Vapour.....	11.3	13.5	12.9	12.1	12.2	11.8	9.6	14.6	12.2	11.9
Precipitation.....	4.44	1.10	5.22	3.08	2.46	1.61	1.77	1.92	1.87	2.83

Again we see the driest July had the second greatest monthly average of water-vapour in the air while the wettest Julys were well down in the list of vapour-content. If these figures are plotted on co-ordinate paper, it will be seen that the correlation between the two pairs of variables is slight but if there is any relation suggested, it is that the most rainfall is associated with the driest air while the most humid air is found in the drouhty months. The very large range of vapour-content between the most humid and the most arid days is worthy of note. Reference will be made to this in later sections. The lower vapour-content at Churchill in summer should also be noted.

CHAPTER V

Seasonal Extremes and Variations

(72) The relation between wind-direction and mean temperature of the day has been investigated for ten Januaries and ten Julys at Winnipeg, Minnedosa, and The Pas. The table of average frequency of specified mean temperatures associated with the eight wind directions or a calm is given herewith. Care should be used in making deductions from this table. It has already been indicated that NW and SE directions are much more frequent than any other. Therefore, the absolute magnitude of the frequency for any temperature-class is expected to be high for these winds. The peak or modal frequencies for each wind considered separately will give best indication of any distinctive characteristics. We note that in July at Winnipeg there are more days with mean temperatures between 65 and 70 F. associated with NW winds than any other temperatures. All the really cool days are also NW days. There are no extremely hot days with NW winds. Going through all the data for Winnipeg, we may set down the following results:

	N	NE	E	SE	S	SW	W	NW	CALM
Temperatures of peak frequency	{ 65 to 70	{ 60 to 70	{ 65 to 70	{ 70 to 75	{ 70 to 75	{ 70 to 75	{ 65 to 70	{ 65 to 70	{ 60 to 65
Temperatures of least frequency	{ 55 and 85	{ 55 and 90	{ 55 and 80	{ 55 and 95	{ 55 and 95	{ 55 and 85	{ 55 and 80	{ 50 and 80	{ 55 and 80

We see that hot days are most often SE, S, or SW days while calm days are the coolest usually but the extremely cool days NW days. East and west days and calm days have the least range of variation,—25 degrees; while southeast, and south days range through a width of 40 degrees.

(73) For The Pas by the same method we have in July:

	N	NE	E	SE	S	SW	W	NW	CALM
Temperatures of peak frequency	{ 60 to 65	{ 60 to 65	{ 60 to 65	{ 60 to 65	{ 70 to 75	{ 60 to 70	{ 65 to 70	{ 60 to 65	{ 65 to 70
Lower extreme.....	50	55	55	50	55	55	50	50	55
Upper extreme.....	80	75	75	85	80	75	80	80	80
Range.....	30	20	20	35	25	20	30	30	25

The warmest days are the south days with west and calm next in warmth. The coolest days show great variation of direction but northeast and east days are not only generally cool but have the least range of variation. These winds are associated with airmasses lying or moving slowly over the middle of the Canadian Shield or over James and Hudson Bays. These masses are seldom associated with calms in northern Manitoba but their southern margins move southward to underrun the warmer air of the plains. Northeast and east winds are, therefore, expected to be cool in northern Manitoba, while stagnant air of calms is likely to have been previously warmed in the lower layers over the western or southern plains in midsummer.

(74) At Minnedosa the fact that wind-directions and speed are not determined instrumentally but are only by estimate of the observer does not allow as much weight to be given to the figures. The very large number of days labelled "calm" probably include a considerable proportion of days with light winds. Otherwise, the distribution of winds follows very closely those at anemometric stations, particularly in respect to the large preponderance of NW and SE winds.

The peak frequencies for each direction resemble those of Winnipeg but a lack of smoothness in the frequency curves is evident. This may be due to extremely local causes in which topography plays a large part. More likely difficulty of the observers in determining directions without an instrument is the major reason for the striking asymmetry of the frequency-polygons. The anemometer at Melita has not been in operation long enough for a similar analysis.

(75) There are several weather phenomena which cannot well be recorded by instruments and for which we must depend upon the observer to keep accurate notes. The occurrence of hail, thunderstorms, fogs, supercooled rain, etc. are such phenomena. Most of our observers do not make notes of these or do so with irregular attention to such occurrences. For this reason the average frequency of these phenomena appears to be much greater at a few points than anywhere else in the province, that is, at the points where we have the most careful observers. A few long records of thunderstorms at points where we believe the observers were especially careful are here given. A thunderstorm in February may be expected to happen three times in a century at Winnipeg while other points have not noted one in this month. Five or six years in a century a thunderstorm occurs in March and about five years in ten years in April. One or two may be expected to occur in May and three or four in June, four or five in July, and two to five in August. After one or two in September the thunderstorm season appears to be generally passed. They do occur, however, in October and November. It will be noticed that the season is late at Norway House but thunderstorms continue into November at the rate of one in four years per century. December and January appear to be free of thunderstorms.

(76) The maximum number of thunderstorms which has been recorded is 39 at Treesbank, 32 at Winnipeg, 30 at Minnedosa, 29 at Treherne, and 30 at Hillview. The smaller number of 19 at Norway House is to be expected on account of its northern situation. The much smaller number at Brandon Experimental Farm is not explainable at the moment but we had better conclude that a poor count is kept. Brandon is so close to Minnedosa that the number noted should not differ materially from that of Minnedosa. The annual average number is 15 to 19 at southern points and 8 or 9 at Norway House. The figure of $7\frac{1}{2}$ at Brandon suggests that only about half the number actually occurring are noted. This, of course, cannot be definitely stated since Brandon is about 30 miles from both Minnedosa and Treesbank and thunder cannot ordinarily be heard at such a distance. Therefore, there may be two paths of high frequency of thunderstorms, one through Minnedosa to the north and another through Treesbank to the south. If these paths are sufficiently narrow, Brandon might conceivably be visited less often than the other two points.

(77) The observations at Treesbank were always so faithfully and carefully made by the Criddle family (of St. Alban's) that the maximum number of 39 per year and 15 in July may be taken as absolutely correct. Winnipeg was always our chief station so that we may assume that careful count was taken there also. For this reason we may deduce that there is an actually greater frequency of thunderstorms at Winnipeg than at Treesbank, averaging two or three more per year at Winnipeg. This suggests that about two or three thunderstorms per year come up the Red River valley which do not affect the territory to the west.

(78) Shorter periods of record have been obtained by combining the records for Graysville and Almasippi and from the records of Mr. Aitken, near Moose Horn Bay. These indicate 21 per year at Graysville and 19 at Moose Horn Bay in the interlake region.

(79) Following will be found a table giving average values of daily highest and lowest temperatures for each month at points with 20 years or more of record. Because of scarcity of stations in the north, Moose Horn Bay with 19 years, and Flin Flon with only 5 years have been included. Maps including all records whether short or long accompany this brochure, but on account of long record the figures in this table have especial value. These normal values may be considered with very close approximation to accuracy as the normal temperatures of the middle day of each month. They are supplemented by tables showing the average extreme highest and extreme lowest temperature of each month. Perhaps it will be well to explain the difference between the two sets of tables. For instance, at Dauphin there are 30 years of records and the lowest temperatures recorded for every day in January of the 30 years are in number 930 all told. The sum of all, divided by 930, gives us 8.7 below zero Fahrenheit as the normal lowest temperature of a January day at Dauphin. Similarly, 930 readings of the highest temperatures for every January day in 30 years yield an average of 10.2 above zero Fahrenheit.

On the other hand, the 30 readings of the absolutely highest reading in each of 30 Januaries, added and divided by 30, give us 36.7 as the highest reading to be expected there in January; and similarly 33.3 below zero is likely to be the lowest point of the month.

(80) Occasionally we get very high temperatures in southern Manitoba. On account of the general use of the Fahrenheit scale in North America, 100 Fahr., from the roundness of the number, attracts public attention. This is very close to 310T. (above absolute zero on the centigrade scale) or 98.6 Fahr. Temperatures of this order have been recorded at Winnipeg in May and on to September. 108 Fahr. (approximately 315 absolute) is the highest ever reached at Winnipeg but 112 Fahr. (317.5 absolute) has been recorded three or four times in the same week in July, 1936, at Emerson. These extraordinary temperatures are not as reliable a criterion of climatic extremes as the averages of all monthly extremes such as listed in the table already mentioned.

(81) If the normal figures for daily minimum temperatures are credited to the middle day of the month and a smooth curve drawn through them, it will be apparent that the rise of the daily minimum is most rapid from the middle of February to the middle of April while the sharpest fall is from the middle of October to the middle of January. If the gain up to the middle of April were to continue unchecked at Winnipeg, the daily minimum temperature would attain a mean value of 80 Fahr. in July while if the falling portion of the curve from October to January is produced backward to July at the same differential rate, it will appear to have fallen from 80 Fahr. in July. Similarly, the corresponding rise and fall in the daily maximum, if continued unchecked, would give a mean daily maximum in excess of 100F. in July. Towards the end of April, therefore, another weather control begins to operate to check the rising warmth of Manitoba. Since the normal daily maximum and daily minimum in July at Winnipeg are actually 79F. and 55F., this controlling force has the effect of reducing the temperature by 20 to 25 degrees below what it promises to attain from the climb in March and early April. Since the curve of minima for Churchill climbs almost steadily until July and then remains practically stationary in August, we can see that the lag in warming over the area of Hudson Bay and the territory of the extreme northeastern portion of the continent is probably the weather control which reacts to prevent southern Manitoba from becoming quite hot in midsummer.

(82) The division of the year into seasons is difficult without some definitions. Spring, for instance, may be taken as the time of first natural growth. Since growth is supposed to take place at a temperature of 43°F., we may choose the date of beginning of spring as the average date of a daily maximum of 43°F. Also, since a mean daily minimum of 32°F. definitely is associated with winter, we may consider winter ends on the date when on the average the minimum rises above the freezing-point of water. The first definition gives the 3rd of April and the second the 26th of April at Winnipeg as the first day of spring. At Norway House we find the 6th of May and the 14th of May for these dates. Taking means, we may say spring begins on the average at Winnipeg on the 14th of April and at Norway House two weeks later. At Churchill we have the 13th of June as the last day of winter on the same basis. At The Pas and Flin Flon Mine the temperature climbs very steeply in the daytime but the nights are cold. Therefore, the days reach spring temperatures shortly before the middle of April while the nights have not become springlike till about the 10th of May. Most of the western districts are a little later than Winnipeg, except in the Souris valley.

(83) As a criterion of summer we might take a lowest night temperature of 43°F. on the supposition that during summer growth is continuous throughout the twenty-four hours of the day. This definition gives us the 27th of May as the beginning of summer at Winnipeg and the 11th of June at Norway House. By the same criterion there is no summer at Churchill since the warmest month does not attain an average minimum temperature of 43°F. At The Pas we find summer beginning on the 2nd of June. For Russell the date appears to be the 25th of June. The nights at this point seem to be very cool although the days are as warm or warmer than at The Pas.

(84) The end of summer should be reached when the night temperatures begin to fall below 43°F. Since at Winnipeg September minima average 43.2, summer ends at this point shortly after the 15th of September. At Churchill there was no summer to have any end but at The Pas it lasts till the 1st of September and at Norway House till the 5th of September. At Russell it ends on the 5th of August.

(85) The beginning of winter may be taken as the date after which every morning may be expected to be frosty. The curves of the daily minima give the following dates. For Winnipeg the 14th of October; Norway House the 7th of October; Churchill the 18th of September; The Pas the 28th of September.

(86) The similarity between figures for The Pas and Berens River is greater than might have been expected since Berens River is considerably further south. It has higher day temperatures than Norway House but lower night temperatures. It appears that the portion of Manitoba to the east as well as north of the Great Lakes of Manitoba have not such a favourable climate for growth as the interlake and southern regions.

(87) The average percentage of each hour of the day for which bright sunshine was recorded during the period 1900-1936 will be found in Diagram (6). The stations are Winnipeg and Brandon in Manitoba but the figures for Indian Head, Sask., are also given. At Winnipeg the brightest period when more than 70% of each hour is in brilliant sunshine is in July from 9 hours to 15 hours and in August from noon to 14 hours. At Brandon the corresponding period is from 9 hours to 16 hours in July; from 9 hours to 15 hours in August. The period with 60% bright sunshine does not begin till April in Winnipeg but includes noon and 13 hours in February at Brandon. The 60% period ends at both places in September although at Winnipeg it is confined to the three hours from 11h. to 13h. Indian Head resembles Winnipeg considerably more than Brandon. These are the only stations equipped with Campbell-Stokes sunshine recorder.

(88) The estimates of the percentage of sky clouded at the evening and morning observation hours have been averaged with the following results.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Winnipeg.....	47	44	51	49	53	55	46	49	52	53	<u>60</u>	<u>56</u>
Minnedosa	43	42	51	50	<u>56</u>	<u>59</u>	48	51	52	53	53	53
Norway House.....	41	38	45	45	45	52	49	50	62	<u>60</u>	<u>68</u>	52
Churchill.....	45	52	38	53	56	52	50	48	<u>59</u>	<u>68</u>	56	50
York Factory.....	50	40	45	52	61	58	61	54	<u>63</u>	<u>66</u>	62	52
The Pas.....	48	45	49	50	52	49	51	52	<u>58</u>	<u>60</u>	67	<u>63</u>

The very small variation throughout the year at southern points and the greater increase in cloudiness in the winter at northern stations is worthy of note. Even on the Hudson Bay coast the cloudiness is quite small. For comparison we have the figures of Victoria from the west coast. Victoria has its dry season in summer, averaging only 5 inches of rain from April 1st to August 31st against 12 inches in the same period at Winnipeg. It also has less precipitation for the year than the average of southern Ontario stations. Its cloudiness variation is very large compared with Winnipeg. Dawson in the Yukon, another point with very low precipitation and with an exceedingly continental climate, shows more variation in cloudiness than Winnipeg. Barkerville as a very high plateau station and Yarmouth, N.S., as an east coast station are also listed for comparison.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Victoria.....	78	71	63	62	59	55	<u>36</u>	<u>39</u>	51	67	<u>78</u>	<u>79</u>
Dawson.....	57	49	<u>44</u>	<u>48</u>	53	58	58	59	<u>63</u>	<u>62</u>	63	55
Barkerville.....	62	58	58	62	64	67	<u>58</u>	<u>56</u>	<u>63</u>	<u>61</u>	71	65
Yarmouth.....	<u>78</u>	71	63	55	58	56	<u>60</u>	<u>56</u>	<u>51</u>	<u>55</u>	<u>71</u>	<u>76</u>

The brightest two successive months have a single underline in all cases while the gloomiest two successive months have a double underline. The tendency in Manitoba is for a maximum of cloudiness in early winter to be succeeded by a minimum in midwinter. At Dawson a gloomy autumn is in contrast with a bright late winter or early spring. On the Pacific coast and the

British Columbia plateau the bright summer is succeeded by the maximum cloudiness in autumn and early winter. On the Atlantic coast a bright autumn is followed by greatest gloom either in winter or spring. Ontario and western Quebec resemble in seasons of cloudiness the Pacific coast. Saskatchewan stations resemble Minnedosa by indicating a slight maximum of cloudiness in May and June and so also does Edmonton. Medicine Hat, however, has a distinct minimum in July and August and a maximum in early winter. Cloudiness is, therefore, only very slightly related to precipitation in Canada.

(89) The incidence of cloud has the well-known effect of checking the rate of fall of temperature during the night when the clouds are low. The period from 1872 to 1936 at Winnipeg was examined to see what difference there might be between the variability of the mean daily maxima and the mean daily minima of temperature. To examine every day would have taken more time than could have been arranged. Therefore, the average of each month of record were taken for January, May, and July. The differences from averages were squared and the root of the mean square tabulated with the following results.

Deviations	January		Minnedosa	
	Winnipeg		Mean Daily Temperature	
	Max.	Min.	Max.	Min.
Standard.....	7.36	7.80	7.87	8.19
Greatest +ve.....	11.9	15.0	12.9	17.2
Greatest -ve.....	-13.3	-14.6	-12.6	-14.6
May				
Standard.....	4.57	3.74	4.64	3.83
Greatest +ve.....	9.4	8.9	9.5	6.9
Greatest -ve.....	-13.0	-11.8	-13.5	-9.4
July				
Standard.....	3.47	2.84	3.33	3.12
Greatest +ve.....	10.2	7.4	10.2	7.5
Greatest -ve.....	-8.4	-5.5	-5.9	-7.6

(90) The variability of the maxima and minima do not appear to differ greatly at either place. In January at both places the minimum is a little more variable than the maximum while in May and July the maximum varies more than the minimum, noticeably so in May at least. This agrees with the cloudiness maximum at Minnedosa in May and June and the cloudiness minimum in January and February. For July, which is nearly as free of cloud as January, the slightly greater variability of the maximum suggests that there may be slightly more cloud at night than by day. There are no figures, however, to check this supposition.

(91) There are some interesting points about the variations aside from their probable relation to cloudiness. For instance, although the average daily minimum at Winnipeg is as likely to be nearly eight degrees below normal as eight degrees above, this assumes a symmetrical or nearly symmetrical distribution of temperatures about a mean value. If the actual departures from normal are plotted in groups of two degrees width, it will be seen that small deviations from the normal are not so numerous as large ones. Thus, at Winnipeg in January the most frequently occurring positive departures of the mean daily minimum are grouped around six to eight degrees above normal while the deviations below normal are in two clusters. The larger number are centred around three degrees below normal and the smaller group around eleven degrees below normal. The mean daily maximum shows four groups. Again in May by far the largest number of Mays have been either two to four degrees above normal or two to four degrees below normal. In July, however, distribution of differences from normal becomes fairly symmetrical about the mean.

(92) There have been some notable anomalies in regard to deviations from the normal which will be seen in table XV. For instance, in January, 1880 at Winnipeg the mean daily maximum was more than five degrees above normal but the mean daily minimum was eight degrees below normal. Such an occurrence points to the probability that the cold waves were

so timed in passing Winnipeg that month that clear skies and rapidly falling temperatures coincided frequently with the night-hours. On the other hand, if the front of a warm wave arrives at a point in the early morning, then the usual daily rise of temperature is superimposed on the increase in temperature caused at the point by the arrival of the warm airmass. On such a day the maximum temperature may be considerably higher than on a day when the warm wave arrived late in the day. The chance of such a timing repeating several times in the same month is not an unlikely one. There is, of course, with airmasses moving across the continent no reason why the front of a warm or a cold wave should pass a given point at any particular hour of the 24 hours of the day rather than at any other. But if the width and speed of movement of airmasses happens to take a suitable configuration, then for a time we can have an apparent periodicity in the passage of such masses. Such months generally show a noticeable difference between the averages of atmospheric pressure for the morning and evening observations. No such periodicity can last for any great length of time although it may be apparent for a month or two. Similar cases may be picked out of the tables given for Winnipeg and Minnedosa for January, May, and July. It may be seen that the deviations of maximum and minimum temperature may often differ by four or five degrees.

CHAPTER VI

Wind Movement in Manitoba

(93) Continuous records of wind from the anemometers at Winnipeg, Man., and Qu'Appelle, Sask., have been analyzed for every hour of the period from 1908 to 1936 at Winnipeg and 1909 to 1936 at Qu'Appelle. During this period, on account of repairs or replacements, the instruments were out of use for only a few hours, except during the year 1920 at Winnipeg and the years 1913 and 1922 at Qu'Appelle. For these years some months were missing or incomplete.

(94) There is no lengthy instrumental record of wind in southwestern Manitoba. The records from Qu'Appelle in southeastern Saskatchewan were substituted for this reason. In view of the very large areas covered by moving airmasses which are fairly homogeneous in respect both to lapse rate of temperature with height and water-vapor content, it was thought that essentially seasonal characteristics for southeastern Saskatchewan should not differ greatly from those obtaining in southwestern Manitoba.

(95) Exception to the paragraph above should be made for any situations in southwestern Manitoba which lie in deep, narrow valleys of the hills supplying run-off to the Souris and Assiniboine Rivers. Records in narrow valleys everywhere show that surface winds are constrained by the contours to very largely blow either up or down such valleys. Therefore, the orientation of such valleys should be taken into consideration, if attempt is made to apply the results hereinafter discussed, to such exceptional situations. In particular, it may be noted, that when only light winds, without any decided gradient of atmospheric pressure, are blowing over a hilly region, reversals of wind-direction may occur during the day. This will be the case with clear weather and low specific humidity with strong surface heating during the day and rapid radiational cooling at the surface during the night. If this occurs in hilly country, the wind may blow up the valley in the afternoon and down the valley at night. This is plainly evident at Calgary in Alberta and in the interior valleys of British Columbia where the contours are, of course, very bold but the effect can occur, although less noticeably, among lesser hills where the slopes are long and the valleys narrow. When the winds are strong with pronounced gradient of atmospheric pressure, the diurnal reversal will not occur. Although there are no anemometers in such exceptional situations in Manitoba, the short record at Melita on the Souris River has been compared with the simultaneous wind-data from Qu'Appelle. The comparison will be found in a later paragraph.

(96) Diagrams 7 and 8 show the comparative frequency of winds falling into five classes. These are (a) calms or light winds up to 4 miles per hour or 6 feet per second; (b) winds from 4 m.p.h. to 15 m.p.h., or 22 f.p.s.; (c) winds from 15 m.p.h. to 31 m.p.h., or 45½ f.p.s.; (d) from 31 m.p.h. to 47 m.p.h., or 69 f.p.s.; (e) above 69 f.p.s. Table XVII gives the same information.

(97) It will be seen that the same general features obtain at both Winnipeg and Qu'Appelle but that the general level of wind-speed is a little higher at all seasons at Winnipeg. At both places the winds of class (b) 6 f.p.s. to 22 f.p.s. are by far the most common. At Winnipeg 70 to 72% of the time from October to March the winds fall into this class, and more than 75% in July and August. At Qu'Appelle about 80% or more occur in July, August, September and October, with a reduction of 5% or more in the winter months. Light airs or calms are at a maximum of about 10 to 12% at both places in December, January, February and July, August. We may say then that there is the greatest tendency to light wind-movement in midsummer while midwinter comes next in order. The tendency to stagnation, or slow, clockwise motion of heated continental air over wide areas in summer and the near-calms associated with the wide-spread masses of dense, intensely cold air of the winter cold-waves, account for this arrangement of speed-frequencies.

(98) The next most frequently occurring class of wind-speeds after the (b) class is class (c), from 22 f.p.s. to 45½ f.p.s. On account of the ability of these winds to move dry top-soils through considerable distances, their seasonal frequency is of more than ordinary interest to the agriculturist. They are least frequent in July and August. At Winnipeg their frequency increases sharply in March, reaching 24% of the time in April and 22% in May, falling off in late June very noticeably. At Qu'Appelle they also peak in April at more than 18%. The secondary peak of class (c) winds is in October and November at Winnipeg, with a tertiary peak in January. At Qu'Appelle the secondary peak is in January and the tertiary in November. The peak-frequency of these fresh to strong winds occurs in spring when the far northern areas are still a source of wintry airmasses while strongly heated air from the continental interior is beginning to reach higher latitudes on the Great Plains. Along the southern and eastern margin of the cold masses violent, intermittent ascent of the heated air takes place, producing squall-winds. Unfortunately, this is the period when, during spells of bright quiet weather, the land is being seeded or during which the seedlings have already appeared. If the squall-winds were generally associated with rain as would be the case on the eastern portion of the continent, little damage would be done by these winds. But since little rain is associated, as a rule, with cold fronts of early spring on the prairies, considerable movement of dry top-soil occurs, interfering with sowing of grain or "blowing out" the seedlings. No reference is made here to regional susceptibility of soils to "blowing." The section on soil-surveys deals with the types and occurrence of soils where dried clays are separable from sands by wind-action. All that can be said here that has any bearing on this question is that there appears to be little variation between such widely separated points as Winnipeg and Qu'Appelle in respect to the annual peak of occurrence of winds of speeds between 22 f.p.s. and 45 f.p.s. and since the annual peak of gale-frequency is from March to May at Williston and Bismarck (North Dakota), we see that the territory affected simultaneously is wide-spread.

(99) The secondary peak of class (c) winds in October and November should have been expected on account of the waves of low-pressure which form on the margin of the early winter cold-waves as they move southward into the warmer regions of the middle west and southwest. This tendency to a rise in wind-speed at the close of the autumn season is common to a great part of the continent. Fairly sharp increase in gale-frequency in November is noted at Detroit, Chicago, Duluth and Cheyenne. Therefore, the rise in frequency of fresh to strong winds at Winnipeg at this season may be regarded as related to the northwestern margin of the territory affected by the paths of autumnal low-pressure waves of the Mississippi Valley and the middle west passing northward to the region of Lake Superior.

(100) The tertiary peak in January at Winnipeg, which coincides with the secondary peak at Qu'Appelle, is also not a local phenomenon nor one confined to a small region. Although this peak is negligible in Canadian territory west of Qu'Appelle except at Victoria, B.C., the zone in the U.S.A. where the annual or the winter peak of gale-frequency occurs in January includes Duluth and St. Paul (Minn.), Williston, and Bismarck (N.D.), Helena (Mont.), Cheyenne (Wyo.) and Seattle (Wash.). This is associated with waves of low-pressure travelling along the southern margin of the intense cold-waves of midwinter. The low-pressure waves form between air of Pacific origin or of southern continental modification and the very cold, dry airmasses of the far northern plains. They travel from west to east but their intensity and general path varies considerably from winter to winter. Neither is their intensity always at a peak in January for that may be reached somewhat earlier or later.

(101) Briefly summarizing the occurrence of class (c) winds (22 f.p.s. to 45 f.p.s.) we may say that seasons when the greatest difference in temperature exists between the northwestern prairies and the southwestern interior of the continent, are those when class (c) winds are most frequent in Manitoba. Conversely, the season when the temperature-gradient flattens between north and south (either because of extensive surface heating over the greatest part of the continent west of the Rocky Mountains or because of widespread cold from north to south) high winds diminish in frequency. We have thus a maximum in spring and a minimum in the hottest part of the summer season.

(102) Winds of gale-force (above 45 f.p.s.) are very infrequent at both Winnipeg and Qu'Appelle. The time of greatest frequency is in March, April, and May at Winnipeg with a pronounced peak in April. The most violent winds, those above 69 f.p.s., occur in March. At Qu'Appelle the greatest frequency of winds above 45 f.p.s. is in February, March, and April while the only instance of winds above 69 f.p.s. was one of four hours in April, 1908, from the northwest direction. These winds of classes (d) and (e) may be regarded as exceptional and very infrequent extensions of the conditions discussed under class (c).

(103) In this and following paragraphs we shall consider the relative frequency of different directions. The direction frequency of each of the classes of wind-speed will be considered separately. Of class (a), very light winds (with calms) not reaching 6 f.p.s., the direction was considered of no importance, more especially because such light airs are known to be extremely variable in direction on the plains. The analysis shown on diagrams of the wind does not violently contradict this assumption, but it is interesting to note that even though there is a wide scatter of events among the eight directions, one or two directions are fairly prominent. In some months at Winnipeg the general tendency is for the light winds to be either northwest or to swing either to right or left of this direction. These months are January, February, March, April, May, October, November and December. The prevailing swing is about the southeast in July, August and September. Oscillation about the southeast and north directions accounts for most of the light winds in June. Secondary preferences of southeast or to the right or left of it are undoubted even if small in April, May, July, August and September, and of south or southeast in November and December. Taking the year as a whole at Winnipeg, we have the impression of a practically constant cause which works to set the wind either from the northwest or the southeast. The occurrence of other directions seems to be merely incidental to the return from one of these principal directions to the other alternative.

(104) At Qu'Appelle from April to July class (b) winds (6 f.p.s. to 22 f.p.s.) also show a preferred swing about northwest and southeast, with southwest accounting for most of the remaining instances. For the remainder of the year northwest and southwest prevail noticeably.

(105) Comparing directional distribution of this most frequently occurring class of winds (b) with the percentage frequency of all winds at stations in the northwestern region of the U.S.A., we find that at Bismarck (N.D.) from 1891-1902 the most prevalent direction is northwest, then southeast and east and north in that order. At Havre (Montana) southwest, west, and northeast is the order of events. At Duluth (Minn.) the most numerous group of winds oscillate from west to either southwest or northwest, while nearly all remaining cases are northeast. (There is undoubtedly some effect from interchange of lake and land breezes here). At St. Paul (Minn.) northwest and southeast are the prominent directions.

(106) Winds of 15 to 31 m.p.h. (or 22 to 45 feet per second) are at Winnipeg mostly from the northwest. Of all winds of this speed 36% are from northwest in January; 34% in February; 33% in March; 28% in April; 25% in May and June; 32% in July; 39% in August; 33% in September; 36% in October; 37% in November and December. The next most frequent direction at this speed is southeast, with 26% of such winds from this direction in January and September; 24% in July; 21% in June, August and October; 20% in February; 19% in April, May, December; 18% in November; 16% in March. The third in frequency are south and north winds, then southwest and west. The directions east and northeast are quite infrequent except northeast in April, May and June.

(107) More violent winds, 31 to 47 m.p.h. (or approximately 45 to 70 feet per second), are almost altogether from northwest and southeast. In February over 20% of such winds are from the north; 72% from the northwest; 6% from the southeast. In March and May about

75% are from the northwest and in April 54%. In July, August and September south and west directions become prominent. The very small number of gales that have ever been recorded at Winnipeg does not permit the percentages to have much meaning. One more or one less gale from any direction would change the percentage materially.

(108) Heavy gales (exceeding 70 feet per second) have occurred in March, April, May but rarely and have been from the northwest altogether except in March where they may occur from the southwest and north as well as from the northwest.

(109) At Qu'Appelle of the winds in the class 15 to 31 m.p.h. 40% to 50% are northwest winds in January, February, March and July to December. There are very few cases of north or northeast winds in any of these months, and most of the winds not northwest are from the southeast, southwest and west. In April, May and June northwest winds account for about 30% to 40% of 15 to 31 m.p.h. winds, while 20% to 30% are from the southeast. During July, August, and September southeast winds account for 15% or more while southwest and west account for about 20% between them.

(110) At Qu'Appelle the winds from 31 to 47 m.p.h. are almost altogether northwest winds. However, in January northwest accounts for about 65% and southeast more than 30%. The same is true of May. In February they are almost exclusively northwest but in March and April west winds show the second highest frequency. In June, July, and August southwest and west winds become very prominent while northwest winds die out in July and August to reappear in September.

(111) Heavy gales have been recorded at Qu'Appelle in April only and then from the northwest.

(112) There were available records for about one year from the anemometer at Melita in southwestern Manitoba. These have been compared with the readings from Qu'Appelle for the same period. This is not sufficiently long for any dependable deductions. The arrangement of the graphs comparing these records is somewhat different from those already discussed. In the case of the Melita records the percentage of all winds is shown by the length of the lines.

(113) It will be seen that by far the greater part of all winds are less than 15 m.p.h. at both Melita and Qu'Appelle for this period. There is a noticeably larger percentage of winds from 16 to 31 m.p.h. at Melita than at Qu'Appelle. In regard to direction of prevailing winds, it is evident that there is a tendency for a clockwise shift of directions at Melita. Thus, the prevalent northwest wind in January, 1937, at Qu'Appelle became a prevalent north wind at Melita. Also the prevalent southwest wind at Qu'Appelle in that month became a prevalent west wind at Melita.

(114) Besides the tables of winds observed at about 15 metres above the ground, there are given figures derived from a very short series of pilot-balloon flights over Winnipeg. It might be well to mention that balloons are in general released only when the weather permits the flight of the balloons to be observed by means of a theodolite. Although the free-lift of the balloon is determined before release and, therefore, the height of the balloon is known at any instant by the product of the time elapsed since release and the known free-lift, the angles of elevation and azimuth cannot be determined once the balloon is lost to sight in a cloud-bank. Occasionally, it can be brought again into the field-of-view by a smart observer after emergence from a cloud, but this never happens with a low ceiling. Therefore, the wind-frequencies at upper levels as indicated in the tables may be taken as representative of fair to fine days only. Most flights encounter cloud at moderately low levels so that the number of cases of observations at 3000 metres above sea-level are comparatively few. Taking a month at random, we find for November, 1936, for balloons released from the Grain Exchange Building at Winnipeg 23 days with figures for 500 metres; 20 days for 1000 metres; 16 days for 2000 metres; 8 days for 3000 metres; 5 days for 3500 metres. On 8 days the flight ended on account of balloon lost in cloud; on 10 days because lost in the distance; on 1 day because flight was into the sun's rays; on 2 days because line of sight lay through an obstruction; on 1 day invisible through falling snow; on 7 days flights were not attempted. During the year 1936 there were flights on a very large proportion of the days and these have been summarized under the following headings.

(115) Since the winds aloft attain much higher speeds than those near the surface, all winds less than 4 metres per second have been grouped without regard to direction. The original

classification was 4 to 15 metres per second, 15 to 31 m.p.s., 31 to 47 m.p.s. and all those in excess of 47 m.p.s. For tabulation these have been converted into approximate equivalents of ordinary usage as follows. Below 10 miles per hour, 10 to 35 m.p.h., 35 to 70 m.p.h., 70 to 105 m.p.h. and all over 105 m.p.h. All above 10 m.p.h. have been grouped by direction. The first level is 500 metres above sea-level which is about 880 feet above Winnipeg. The other levels are, respectively, one, two and three kilometres above sea or approximately 1520 feet, 5800 feet, and 9082 feet above Winnipeg. The frequencies are expressed as percentages of the total number of observations at each level for each month. See Table XVIII.

(116) At the 500 metre-level northwest and south winds were generally prevalent. This differs from the long term average of northwest and southeast at the ground. Not much significance should be attached to this discrepancy because at ground level in 1936 southeast winds did not become prevalent until July and fell off very noticeably in frequency after September. Therefore, only the relative turning of the winds from one elevation to the next need be considered. The great prevalence of winds from the north, northwest, and west or southwest at high elevations even in those months with considerable frequency of south and southeast winds at lowest levels is worthy of attention. The high velocities at 2000 metres in November, 1936, may be noted. On November 27th the wind attained 114 miles per hour from the N and NNW at 1500 metres and 117 miles per hour at 2000 metres.

(117) The table for 1936 is supplemented by a summary of 5 years for April, May, June for which flights at Winnipeg and Lac du Bonnet were available. This short record will be chiefly useful in the present instance to indicate the relative infrequency of south winds at high elevations. While there are a fair number of cases of southeast winds, one should remember that Arctic airmasses which have proceeded southward to James Bay will have Arctic air returning to the interior on the southern margin of such an airmass. Such southeast winds, associated with returning Arctic air, should be distinguished from air coming up the Mississippi and Missouri valleys. The latter will carry much more water-vapour and will be relatively warm. No such distinction was made in preparing the summary. However, south winds may be taken as indicative of water-vapour transport and so also southwest winds but to a lesser degree.

CHAPTER VII

Relation of Weather Variations in Manitoba to General Atmospheric Circulation

(118) Having reviewed the measurements of temperature, rain, snow, wind, water-vapour, cloud, and sunshine, so far as available from observations in Manitoba and adjoining regions, it may be useful to see how the variations of Manitoba weather, from season to season, and from year to year, depend upon the circulation of the atmosphere as a whole. To keep the discussion brief, we shall confine our attention almost exclusively to the atmosphere of the northern hemisphere and to the lower levels. Also, it will be well to state at the outset that there are innumerable questions about the weather which might easily occur to anyone but which are at present unanswerable. The explanation which follows is based upon measurements made at many points over the globe, not only at the surface but at levels up to or beyond 20 kilometres. The upper level data are not very numerous yet and they are still entirely missing over a great part of the earth. The labours of many meteorologists have gone towards analyzing these and towards constructing a theory of the weather which will incorporate all that has been discovered. There have naturally been many assumptions made to fill gaps in the framework of the theory which are not yet demonstrably true. Earnest discussion over a period of years has eliminated faulty assumptions so that the whole theory so far as it goes seems now very sound. It does not, however, reach far enough to allow seasonal forecasts to be made. There are not yet sufficient data covering the earth at all levels to go farther without suppositions whose possible truth cannot at present be checked.

(119) For a brief synopsis of Manitoba's position relative to the atmospheric circulation it will be well first to recall a few fundamentals of meteorology. (a) The atmosphere is densest at the surface of the earth and becomes rarer with increasing height. The decrease of density with height is such that one half of the total mass of the atmosphere lies within the first 18,000

feet but the next layer of 18,000 feet contains less than a further quarter of the whole. In fact, three quarters of the total mass is below seven miles above sea-level. (b) Dry air consists mainly of nitrogen and oxygen, about 99% of the volume, except at very high levels. The remaining 1% is nearly altogether argon but traces of other gases can be detected. The whole mixture constitutes dry air. (c) Water-vapour may enter the same space which has been previously occupied solely by dry air. When it does so it acts like another constituent gas, exerting its own pressure. Therefore, if the pressure is to remain the same as before, the entry of water-vapour into a volume of dry air must be accompanied by a displacement of a compensating mass of dry air beyond the boundaries of the given volume. (d) The amount of water vapour that can enter and remain within a space is dependent solely on the temperature, which, in turn is, of course, dependent upon the combined energy of the dry gases and the water-vapour. These ideas are difficult to state clearly in words but it will be probably sufficient for our purpose to say that the hotter the dry air the more water-vapour it can maintain in the state of vapour. The total mass of water which at a given temperature can be kept in a state of vapour in a given volume, at a given pressure, can easily be found from a copy of psychrometrical tables. When all the water-vapour is present which can be held, the space is saturated or, as is usually said, the relative humidity is 100%. (e) Any decrease of temperature of a saturated volume will be followed by decrease in the amount of water held as invisible vapour, and conversely a volume of air which is not saturated at existing temperature can be brought to saturation by sufficiently reducing the temperature. This temperature, at which previously unsaturated air becomes saturated, is called the dew-point. This reaching of the dew-point is often observed in Canada when relatively warm and moist air passes over much colder ground. The chilling of the air immediately above the cold ground may be sufficiently large to bring the lowest air to or below the dew-point. The condensation of that proportion of the water-vapour which can no longer be held is made visible to the observer as a ground-fog. (f) On account of the fact that ordinarily the temperature of the atmosphere decreases with height at about 1° F. for every 300 feet of ascent, the temperature of the higher layers of the atmosphere is too low to maintain water as vapour. Also, the amount of vapour necessary to saturate a given volume decreases for the same reason with height. If the atmosphere over Manitoba on an average July day were saturated at every level and then the whole amount of water removed by an enormous lowering of heat and spread out over the surface, it would be equivalent to a rainfall of about one and one half inches in southern Manitoba and considerably less in the northern districts. (g) Equal volumes of water-vapour and of dry air differ in density. The water-vapour is lighter than the air by about 5 to 8. Since water-vapour added to dry air displaces an equal volume of dry air, a cubic foot of moist air has less weight than a cubic foot of dry air at the same pressure.

(120) In what follows we shall use the term "airmass" although it will seldom be possible to define the boundaries of a particular body of air. In general such airmasses as we discuss will be portions of the lower atmosphere only. One of the characteristics of an airmass will be the proportion of water-vapour to dry air within it. Since the temperature above 6 km. or 3½ miles is too low to sustain appreciable amounts of water-vapour, we shall be unable to describe an airmass by its vapour-content beyond this level which is about the level where cirrus clouds are encountered. But if at the surface of the earth we find a zone on one side of which very dry lower air is encountered while relatively moist air exists in an opposite direction along the surface, we can say that two different airmasses are involved. If we find further that both at the surface of the earth and at moderate altitudes different directions of motion are taking place in these two airmasses, we may be able to define approximately a partition between the two masses. If on opposite sides of this partition we find not only different proportions of water-vapour to dry air and different directions of motion but also different rates of fall of temperature with height, we shall have fairly well established the reality of two distinct airmasses. Further than this, we may by measurements of temperature, humidity, etc. (say by instruments carried aloft by an aeroplane) establish that there is a height where there is a more or less abrupt transition from air with one set of characteristics to air of quite another character. In general, such abrupt differences, either in a direction measured along the surface of the earth or measured vertically, are confined to the troposphere. This has a depth of about 20,000 feet in the polar regions and of about 50,000 feet over the equator. Over the middle and polar latitudes, however, the height below which changes due to convection are operative from day to day cannot be regarded as constant. During the coldest portion of the year in high latitudes, the depth of the most disturbed region over Canadian areas seems generally to be least but highest in midsummer. At

least this appears to be true from the observations above Calgary, Alta., and above Goderich, Ont. The boundary of the disturbed region is usually defined by the level where temperature ceases to diminish with height, there above remaining sensibly uniform or increasing for some distance. This boundary is called the tropopause. It is highest over the equator, at about 17,000 metres, and apparently lowest over the poles, at about 7,000 to 9,000 metres. Over Calgary it apparently varies from 6 or 7 km. to 10 or 12 km. or more. The levels still higher, although called the stratosphere, are not without considerable day-to-day changes. Generally the height of the tropopause seems to be loosely related to the mean temperature of the earth's surface in the region containing the point above which the height of the tropopause is measured. However, in the remarks which follow where the word "airmass" is used we shall generally understand that the characteristics which determine an airmass have been considered horizontally and at very moderate heights above the earth's surface. Midway between the boundaries of an airmass we shall be unable to assign a definite roof to our airmass. If there were such a roof, after passing through it, we should find a sharp change in characteristics of the air. In general, however, over the centre of an airmass any such roof which should theoretically exist has been masked by general diffusion.

(121) Airmasses may be recognized in motion from the measurements of pressure, temperature, humidity, wind, precipitation, and cloud which are made at fixed hours daily at several hundred points on the North American continent and on ships (giving their position) on the Atlantic and Pacific Oceans. There are regions where airmasses acquire by lengthy sojourn or slow travel fairly definite characteristics. The airmasses which appear first in the lower Mackenzie River valley in winter have apparently moved inland from the Beaufort Sea. There is a region in Russia (around the lower portion of the Lena valley and thence eastward through the Yakutsk territory) which averages about 50 to 60 degrees below zero Fahrenheit in January and where on rare occasions temperatures of 90° F. below zero have been recorded. It may be that our "polar continental" airmasses drift along the Beaufort Sea from this region. In any case they are characterized by very low temperatures in the lowest layers and are practically dry air. Their general drift on the North American continent in early winter is up the Mackenzie valley to Saskatchewan and Manitoba. Thence they move either (a) southeastward across the Missouri valley and the Mississippi region to the tradewind zone off Florida or (b) eastward across the lower portion of the Canadian Shield to the St. Lawrence valley and the northeastern states to the north Atlantic. In general, as the season advances, they advance more rapidly eastward and less rapidly southward. In summer airmasses with much the same characteristics appear to come from the Canadian Arctic Archipelago and drift eastward and southward. No distinction between these two kinds of airmasses can be at present made. At times both may be plotted on a map simultaneously entering upon our northern territories. Whether, even then, they are distinct bodies of air cannot be determined. They are very important to Manitoba for two reasons. (a) They bring periods of great cold in winter. (b) They appear to be very necessary for the production of rain in Saskatchewan and Manitoba.

(122) Another type of airmass is at present called "Polar Pacific." At a more remote time (perhaps a week or two earlier) before they enter upon the British Columbian territory, they were probably of the same character as the polar continental type. By travel over the waters of the north Pacific, they acquire some warmth in their lowest layers and pick up a little water-vapour. In an earlier section mention was made of the difficulty in understanding how these polar Pacific airmasses cross the Cordilleran mountain system on to the Great Plains. The very lowest and relatively moist layers may often be lifted above the air of the interior of British Columbia to reach the Great Plains as an upper sheet, but eventually we find an airmass upon the plains which is dry but warmer in the lower layers than polar continental air. At considerable heights there may be little or no distinction possible.

(123) Both these polar airmasses may appear to come through Alaska at times. In some cases a type which might be called Behring Sea air can be plotted upon the daily weather maps. In winter it is an extremely cold variant of the polar Pacific type and in summer it cannot be distinguished from polar continental. All these types, because of the extreme dryness of their lower layers, take up moisture as they advance. Since the amount of moisture that can be taken up depends upon the temperature, the warmer they become the more desiccating they become. Their low moisture-content permits their lower layers to be greatly influenced by the surface of the region over which they advance. In particular, the Northwest Territories in

winter are surface-frozen and at least lightly snow-covered. The lakes are frozen over. Surfaces are, therefore, excellent radiators of heat while nights are so long that incoming radiation is largely absent. Given an airmass with practically no vapour-content and so nearly transparent to heat radiation, the surfaces become exceedingly cold. The lower layers of the airmass take very low temperatures from the cold surface, or if originally very cold, they have no opportunity of gaining heat. A polar continental airmass, therefore, remains cold while moving southward and eastward over the Canadian Shield and brings very low temperatures to Manitoba.

(124) In summer when the surface is exposed to incoming radiation the greater part of the day, the land areas west of Hudson Bay heat more strongly by day than the icy waters of north-eastern Canada. Airmasses of cold, dry origin are, therefore, more quickly warmed in their lower layers when passing up the Mackenzie valley to Saskatchewan than when passing by way of Hudson Bay to northeastern Manitoba, northern Ontario and northern Quebec. When rapid warming is taking place at the bottom of these masses, largely by contact with the soil, they take up a little moisture from lakes, streams and soil but still remain very dry. Passing far south, they allow high temperatures by day and sharp falls of temperature by night. Should such an airmass be forced by changes in the continental circulation to send "returning" polar continental air back into Canada, we experience very hot and dry summer weather.

(125) Polar Pacific air has much the same characteristics but in winter generally is associated with milder weather in western Canada and in summer heats also very rapidly. Since the travel of Pacific airmasses is generally in summer over a long path already strongly heated, entry of such air into Canada from a southerly direction brings scorching, dry heat to the wheat-fields.

(126) Air from fairly low latitudes of the Pacific, whatever its more remote origin, generally has had a long history over warm waters. Therefore, it carries considerable water-vapour. Such masses bring very heavy rains to our Pacific coast when lifted above continental air. The distinction between their subsequent history over the prairies and the subsequent behaviour of polar Pacific airmasses has not yet been determined. That they affect the Rocky Mountains even on their eastern faces is indicated by a secondary maximum of precipitation in November and December.

(127) Airmasses from the Arctic latitudes of the north Atlantic do occasionally appear above northern Manitoba when raised aloft by riding up the slope of colder and dryer continental airmasses. Also continental airmasses which have passed over Hudson Bay or Labrador may have characteristics somewhat similar to Arctic Atlantic air. This occurs when air with a westward directed motion along their southern margins has acquired by passage over Hudson Bay or waters off the Labrador coast some water-vapour at a comparatively low temperature.

(128) The airmasses which carry to the North American plains the greatest load of water-vapour are those which move up from southerly latitudes of the Atlantic. With those which move northward east of the Appalachians, Manitoba has only indirect concern but by those which move west of the Appalachians, Manitoba weather is greatly influenced. These airmasses seem in great part to have been of polar or north Pacific origin. Passing southward and eastward over the continent, they reach the tradewind zone. The returning air on their western margins shows more or less tropical characteristics according to season and the time elapsed since the eastern margin has reached to tropical or sub-tropical latitudes. In eastern Canada these tropical airmasses may be observed at the surface of the earth but often only as air aloft. In western Canada it is almost altogether encountered only as an upper airmass.

(129) When two airmasses of differing characteristics at their lower levels are moving, whether in the same direction or not, they can exist side by side without material diffusion. If their speeds are in differing directions or if they are moving in the same direction but at different speeds so that a counterclockwise differential motion results for any portion of the warmer and moister airmass, a slow vortical whirl develops and passes along the boundary between the distinct masses. In the diagrams successive steps in the cyclogenetic process are depicted. However, for a further conception of what is generally called the Norwegian theory, we must remember that the presence of water-vapour in the warmer air has rendered it lighter than the dryer and colder air on the other side of the division between the airmasses. Therefore, the partition

between the masses is conceived as a sloping surface with the warmer air riding up over the colder mass, or the cold mass holding to the lowest levels and underrunning the warmer mass. The slope may not always be at the same inclination but the line where it cuts the ground may extend for many hundreds of miles. Along such a warm or cold front there is a general tendency to precipitation for the warm, moist mass must cool where it ascends. The cooling of dry air is at the rate of about $5\frac{1}{2}^{\circ}$ F. for every 1000 feet of ascent, but for saturated air at the rate of about 3° F. for each 1000 feet of ascent. While this gives a tendency for the moisture lifted up along the front to be condensed if the ascent reaches a sufficient height, yet no appreciable quantity of rain could fall along the front. For continuous heavy rain we must have a continuous rise of moist air up the slope, fresh masses of water-vapour rising to take the place of that which has been condensed. Here the vortical whirl moving along the frontal surface must be considered as essential. A counterclockwise circulation develops around a centre of falling pressure. Masses of air converge towards this centre and a large part of the warmer mass is steadily lifted to form an upper sheet above the colder air either in the front or the rear. The point of lowest pressure moves along the front and appears to coincide with the foot of a perpendicular which passes aloft through the region where convergence has reached a maximum. Eventually the supply of moist air is cut off from the vortical whirl and the vortex dies out. In the meantime, the frontal surface has moved along with the momentum of the cold airmass, while the vortex has travelled along the moving front. The resultant motion of the centre of lowest pressure is generally from northwest to southeast, from west to east or from southwest to northeast, according to the original orientation of the frontal surface when cyclogenesis took place. Very rarely we have a motion also from south to north. Such cases are of low pressure centres moving from Utah to Alberta and these cases have given the very heaviest type of rain on the prairies.

(130) The accompanying diagrams show the process both in plan and elevation. The tongue of warm air which lies between the warm and cold fronts is raised above the cold air at both fronts. At the warm front the rainfall is heavier and more continuous while the cloud area is larger. At the cold front ascent of warm air is more violent. It is often accompanied by squalls at any point as the cold front passes that point and the direction of wind suddenly shifts from southerly to westerly. A period of apparently clearing weather may ensue after the passage of a warm front for a person who is situated south of the centre of lowest pressure. In this case the warm sector passes him to be followed by the cold front with a short period of squalls and precipitation. After the cold front passes, the temperature generally falls and clear weather with a westerly or northwesterly wind follows. However, the temperature at the ground in summer may not be distinctly different on either side of a front. Turbulence in the lowest layers and local heating from the ground render the temperature a poor criterion of the position of the front. At a moderate elevation temperature should be a better criterion, while wind-direction and pressure change are more dependable criteria. During the daytime the ordinary rise of temperature in summer may cause a temperature discontinuity at the ground to disappear although it may be fairly well marked at night. Imperfect as the theory may be at present, in practice for daily forecasts along the airways of the world it has proved of such value that this method of analysis has been universally accepted. All types of rainfall for which we cannot account by the process outlined can be ascribed to instability of airmasses due to local heating under special circumstances. Such other types account for very little rain in comparison with frontal rains. We shall, therefore, consider how the motion of the airmasses which we have described, by following fairly consistently, preferred paths, build up the climate of Manitoba.

(131) In winter polar continental masses may exhibit a frontal surface which divides a new outflow of polar air from older polar air which has been somewhat modified on this continent. On the other hand, a fresh outflow of polar continental air may have polar Pacific air immediately to the south of its front. In the first case there is very little moisture on either side of the front and no precipitation can be expected. The dividing line between the fresh outbreak and the older air will run across the Mackenzie valley towards Hudson Bay or Strait. The advance of the new front will bring somewhat lower temperatures to Manitoba following a period when a very slight rise of temperature has been noted after a severe cold wave. In the case of a polar front advancing against polar Pacific air which is covering the prairies, the passage of the front will be accompanied by a steep fall in temperature. If the polar Pacific air has been for some time on the continent, there may be a little precipitation along the front accompanying the passage of a low pressure wave along it. In summer a front of polar continental air is likely to have

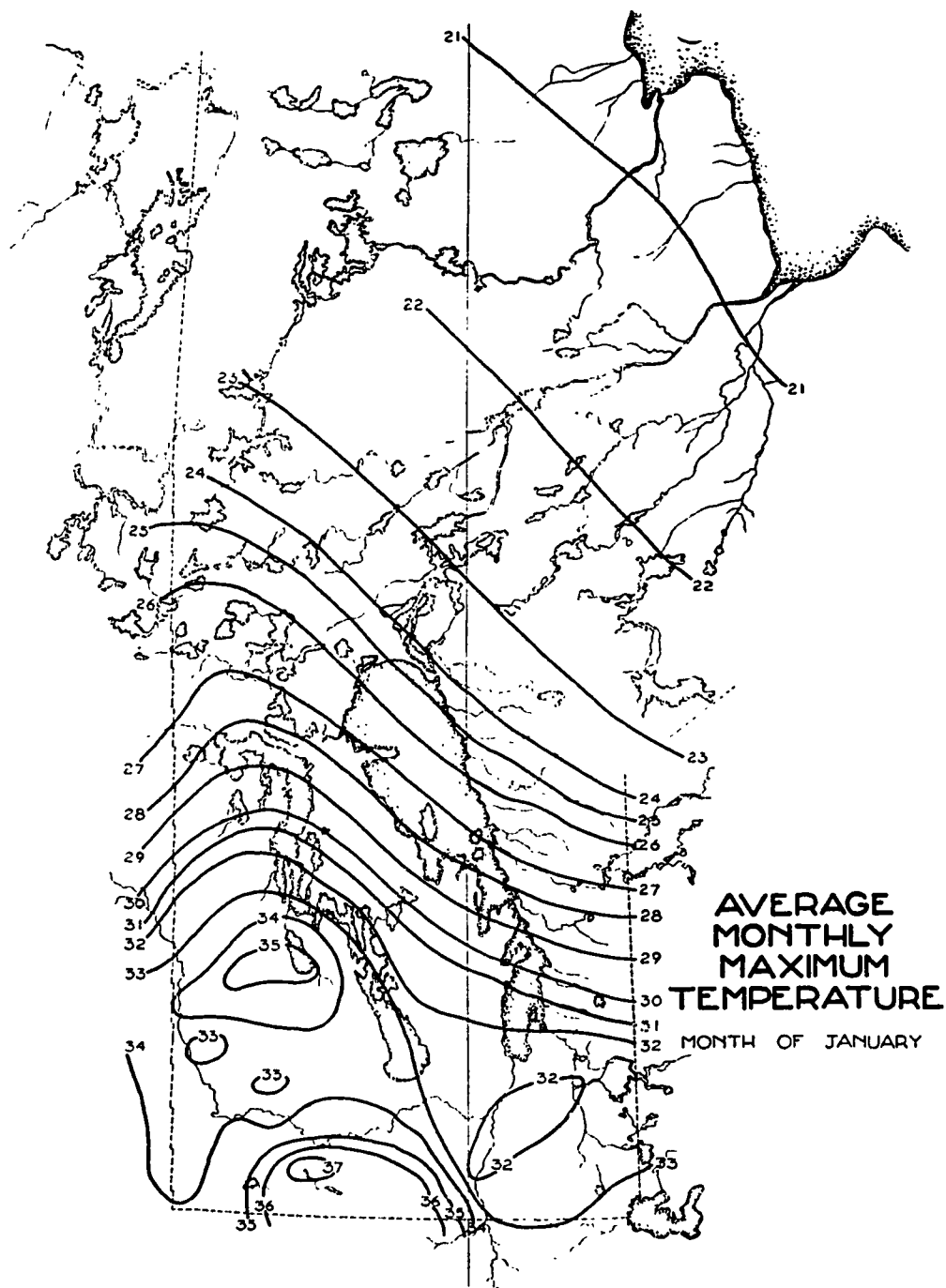
precipitation along it regardless of the type of airmass south of the front. This follows because all strongly heated airmasses have picked up considerable water-vapour. As has already been shown by tables of humidity, the driest summers on the prairies have on the average the greatest absolute humidity. This arises from the invasion of the prairies by airmasses heated on the continent. They carry water-vapour over the wheat-fields but there is lacking the mechanism to precipitate this vapour. To cause convergence with continuous cooling of vaporous air towards some region of the prairies, a cold front is necessary. Quite often in droughty summers a cold front may be found advancing up the Mackenzie valley and some promise of rain on the prairies may be hopeful. Very little may result, however, and the air behind the cold front is found to be heating very rapidly at the surface of the earth. Several cases of this type may be found on the weather maps of 1936. Although there are insufficient aerological data yet from this region to permit any definite knowledge, yet the only reasonable surmise at present is that airmasses which move up the Mackenzie valley in summer are not always of the true polar continental type. Those which appear to move out of the Arctic Archipelago in summer seem to advance upon the plains much farther with retention of a vigorous polar front. The rainfall of our prairie provinces is, therefore, very dependent upon the circulation of the atmosphere in polar latitudes in summer. Without increase of our knowledge of polar aerology, little more can be said, but we may summarize our discussion in the following paragraphs.

(132) The most widespread droughts on the North American continent are no doubt associated with very large spread of air containing sufficient water-vapour for generous rains. During such periods intense heat prevails upon the Great Plains from the Gulf of Mexico to the Arctic circle. With intense heating from below water-vapour is carried upward from below and sufficient instability may develop to produce local showers. The probability of such local showers is quite high in southern latitudes but very low in the north. Such periods of stagnation can be ended only by the advance of a vigorous cold front. Very droughty summers have long intervals between the appearances of such fronts but why the delay cannot be explained. Cold airmasses in such years can be observed to leave the eastern portion of the Canadian Arctic islands and move towards the north Atlantic while the northwestern portion of the continent remains warm.

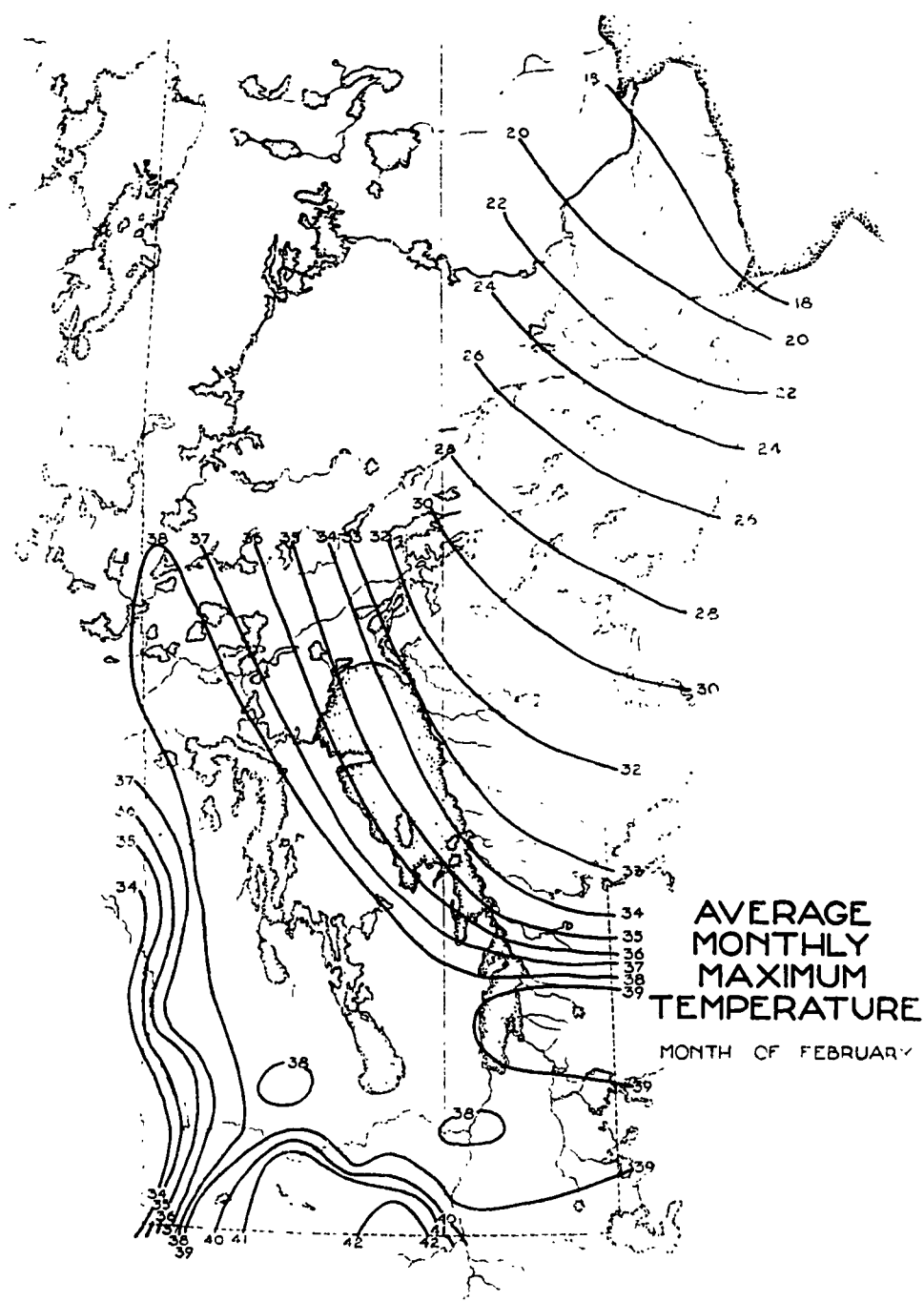
(133) The breaking of such a drought is often accompanied by extremely heavy rains. The intense surface heating prior to the advance of the vigorous cold front has served to carry water-vapour up to considerable heights so that there are great potentialities for heavy rain. The most remarkable rains occur after the plains have been invaded by a very wide airmass, of high surface temperatures and very considerable vapour-content when pronounced cold fronts move from both northwest and northeast towards mid-continent. An ideal case begins with a cold front of what appears to be air from the Behring Sea moving into northern British Columbia. A low pressure wave forms on the front with the heated air of the northern prairies forming the warm sector. Towards the vortex, as it moves slowly southeastward, a great volume of air is set into very slow counterclockwise motion. This brings much continentally heated, sub-tropical air to higher latitudes. If now a cold front advances from the Arctic islands down the western side of Hudson Bay, a period of intense cyclogenesis follows during which the prairies are traversed by low pressure centres involving the lifting and cooling of a great part of the airmasses which from a broad base upon the Gulf of Mexico extend northward to an apex on the prairies. The summer of 1901 provided many cases apparently of this character, although the network of northern stations was very poor at that time and definite construction of polar fronts on the maps of that year is impossible. April, May, and June, which is usually the dry season in the Fraser valley, were excessively wet that year. In April and May quite high temperatures were reached in far northern districts, Fort Chipewyan reporting 82 in May and Churchill 80. Precipitation was quite high for the season in the spring in the far north. Calgary had 7 inches of rain in June spread over 18 days while Medicine Hat had over 6½ inches in May, or about one half of an average year's precipitation, on 10 days. Edmonton had over 11 inches in July and had 16 rainy days in June. Swift Current had over 10 inches in May, June, and July and Qu'Appelle about the same in June and July. Minnedosa had 6½ inches in June and about 11 inches in May, June and July. Winnipeg had 10 inches in June spread over 16 days and Brandon nearly 8 inches. As high as 24 inches for the rainy season was reported from some points. So far as can be determined from the observations available for that year, the resultant motion of airmasses could be graphically expressed on the average by a low pressure centre between Medicine Hat and Swift Current.

(134) Maps of average temperature and precipitation for the continent show that in an average summer the extreme northwestern portion of the continent ceases to be the source of intensely cold air which it is in winter. The isotherms run northward from southeastern Manitoba towards the Yukon but trend downward again through the Rockies and the Selkirks. There are in summer, therefore, two tongues of warm air pointing northward. One is in the interior valleys of British Columbia, one along the prairies to the Mackenzie valley. On the other hand, the Hudson Bay region remains cold with the lowest temperatures around the pole. Therefore, in summer the polar basin is the source of cold outbreaks. The path of the outbreaks is by Behring Sea and from the Arctic islands of Canada to Hudson Bay. In summer when there are no vigorous outbreaks or very few these tongues of warm air become stagnant and droughts prevail even though the water-vapour content is high. When, on the other hand, polar outbreaks are numerous in summer much dry, cool air is moved upon the prairies. Therefore, the average vapour-content is lowered. However, cyclogenesis causes frequent rains along the cold fronts. Thus, the paradox of driest air in the wettest summers arises.

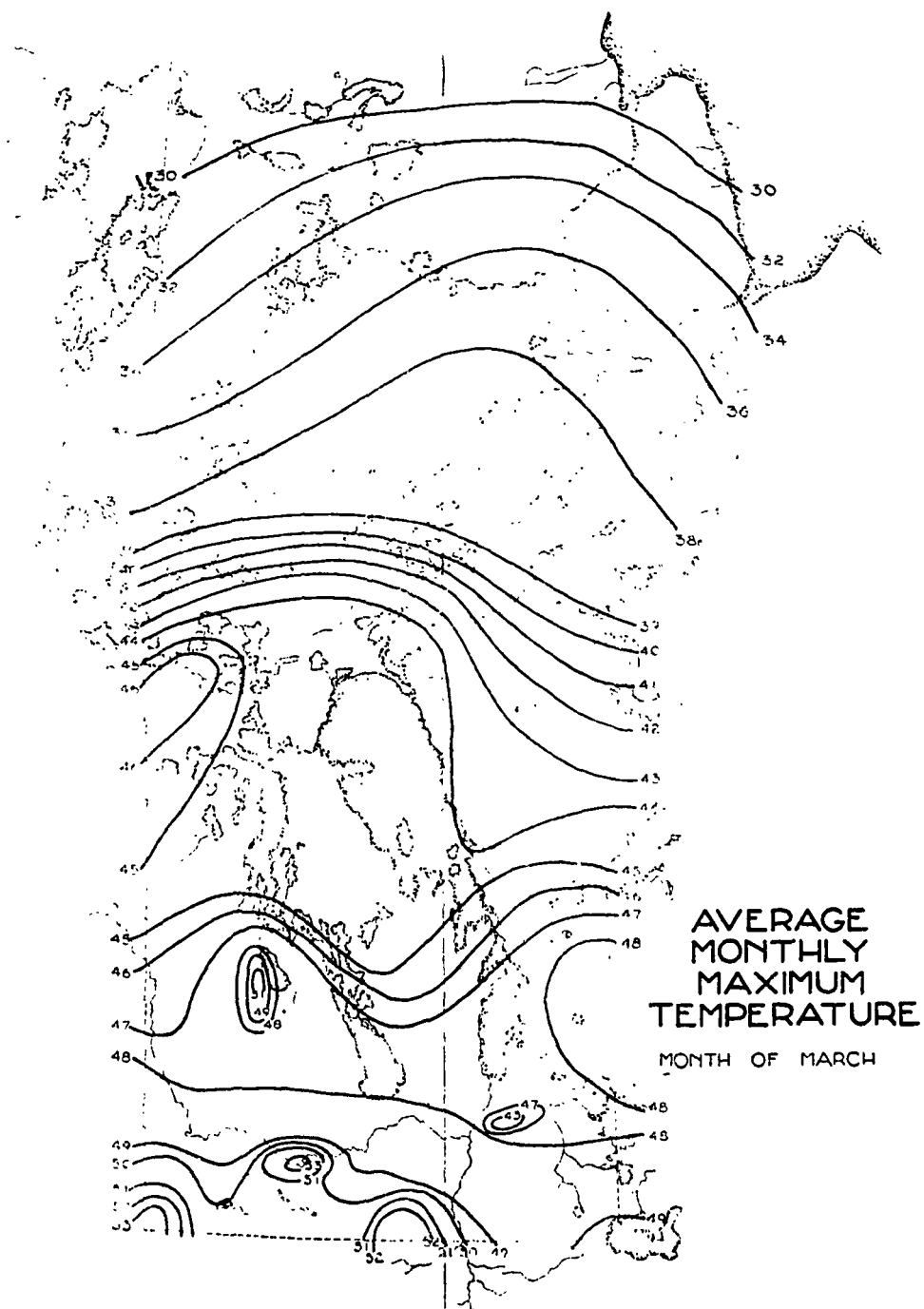
The foregoing brief sketch of the meteorology of the prairies may serve to explain some of the peculiarities of Manitoba climate which appear in the tables and maps accompanying this section of the Manitoba Economic Survey. The theory, however, of weather changes by the forward movement of airmasses of distinct characteristics is in a formative stage. From frontal surfaces of discontinuities near the ground, the theory is in process of amplification to consider the role of moving air sheets in superposition. Very little aerological data for this purpose have been obtained in Canada.



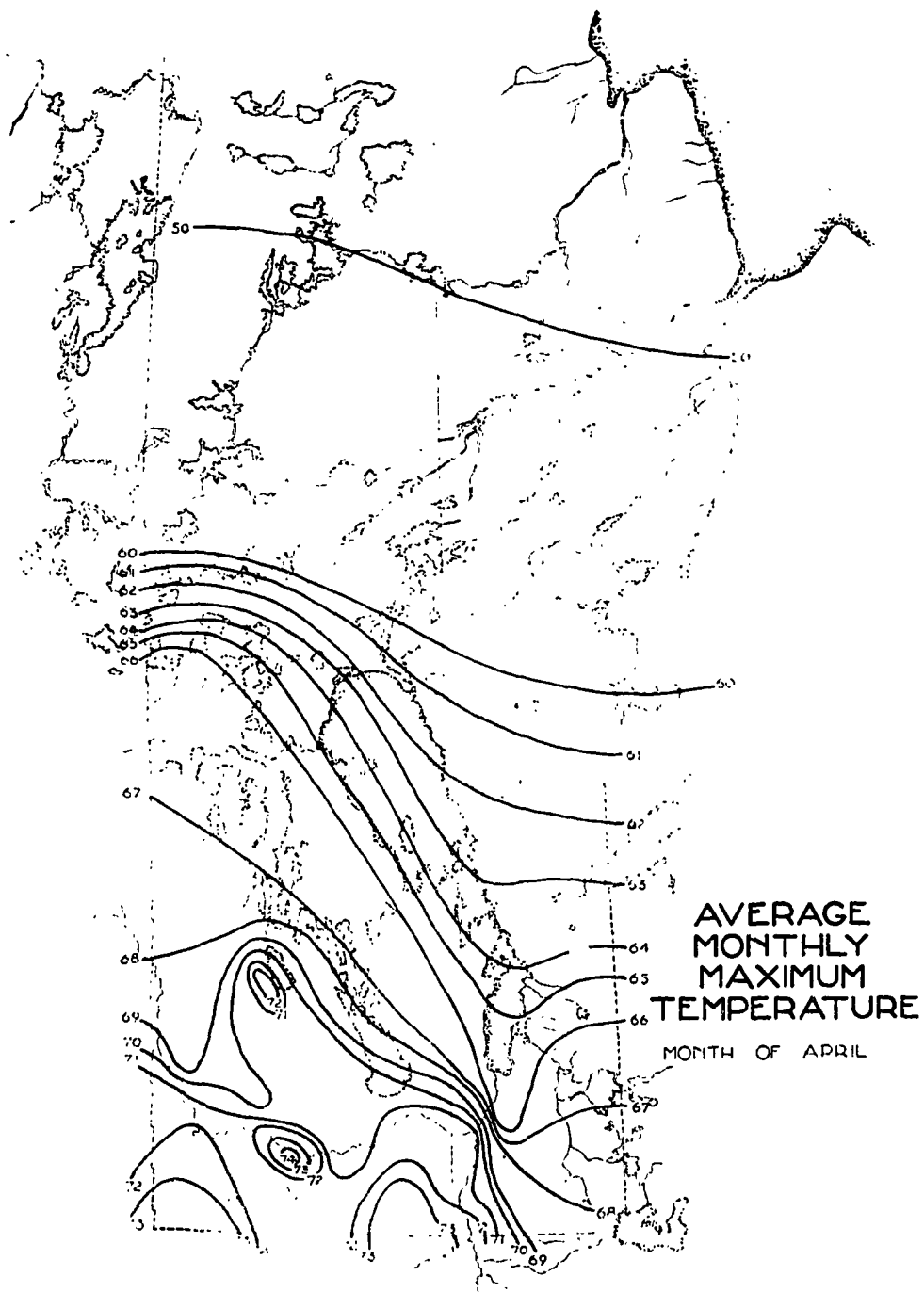
(1) The highest temperature reached in each January of record has been averaged for every observation point. This monthly maximum temperature is the extreme temperature which may be expected to occur at least once in January. Some January day might reach 20F. to 25F. in the region between the Great Lakes of Manitoba and Hudson Bay. In the region south of the Assiniboine river and between the Red and Souris rivers 32F. to 37F. may be expected to occur on at least one day in January.



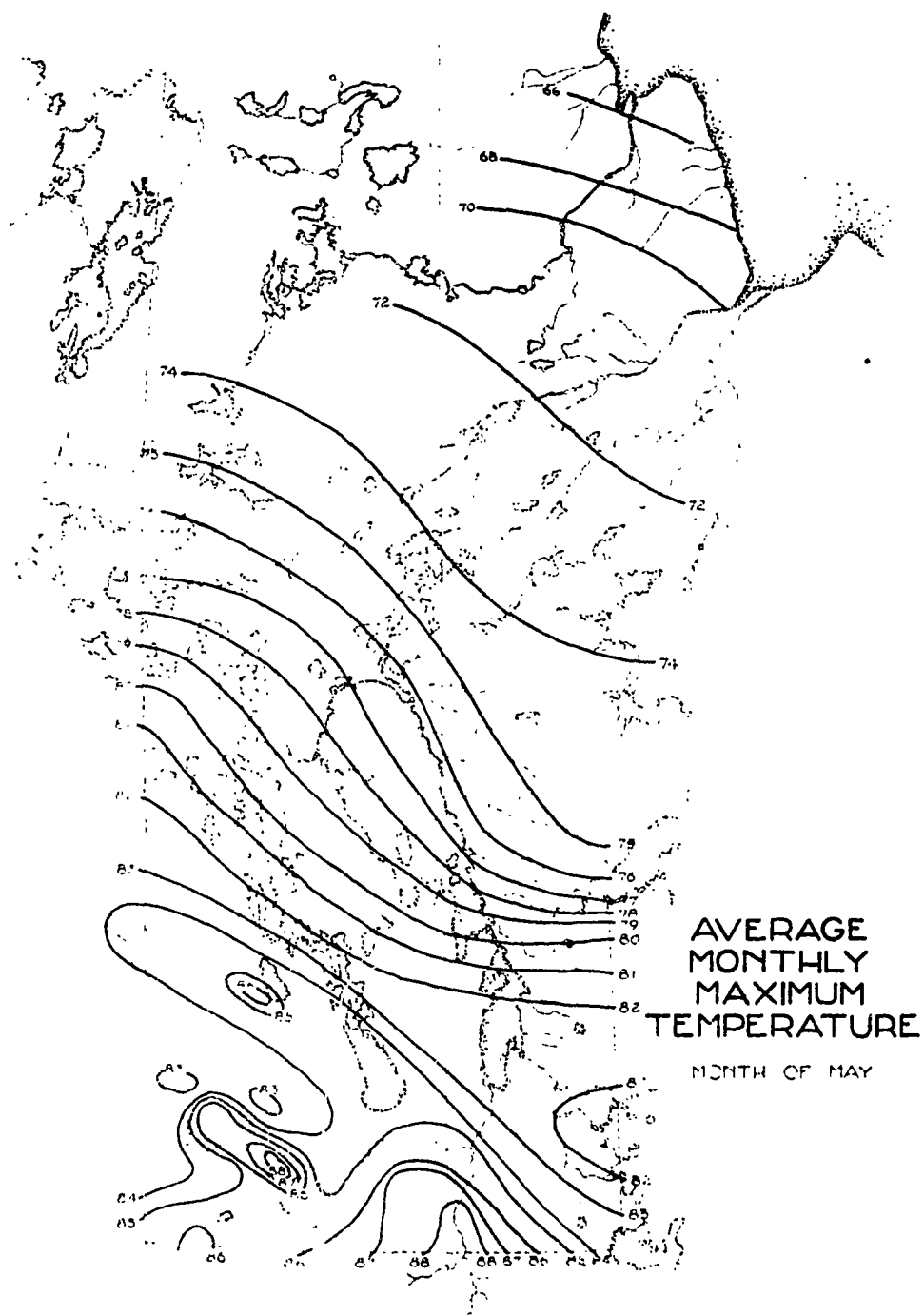
(2) In this month again the monthly peaks of temperature are highest in south-central Manitoba. There is evidently a climatic boundary running northwest and southeast just west of Lake Winnipeg and another running through the Porcupine, Duck, and Riding Mountains region. Between these boundaries we have a region where a few quite mild days may be expected in February. On the shore of Hudson Bay nothing higher than 17F. or 18F. may ordinarily be expected although 29F. has been reached in two or three Februaries since records began. In the extreme south-central region 50F. or higher may occur once in 30 or 40 Februaries.



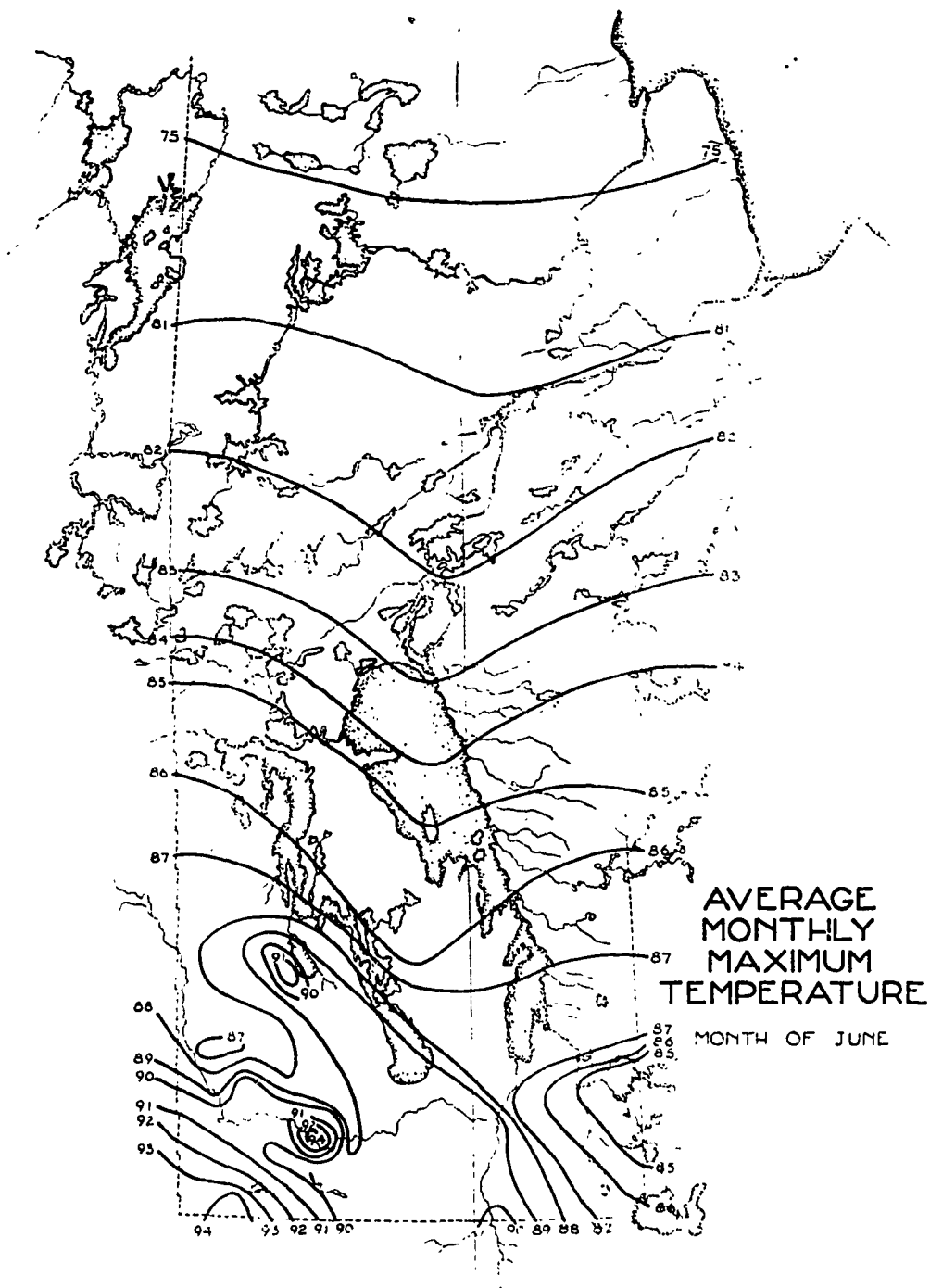
(3) In March the boundary between the regions where occasional warm afternoons are most likely and most unlikely to happen, respectively, has fallen back to the immediate north of the Great Lakes. The effect of the hilly region is also lessened. The interlake region still resists the attainment of high temperatures. A temperature of 75F. or even 80F. may be recorded once in many years in the south-central region. In the Hudson Bay region a peak of 50F. is an extremely rare occurrence.



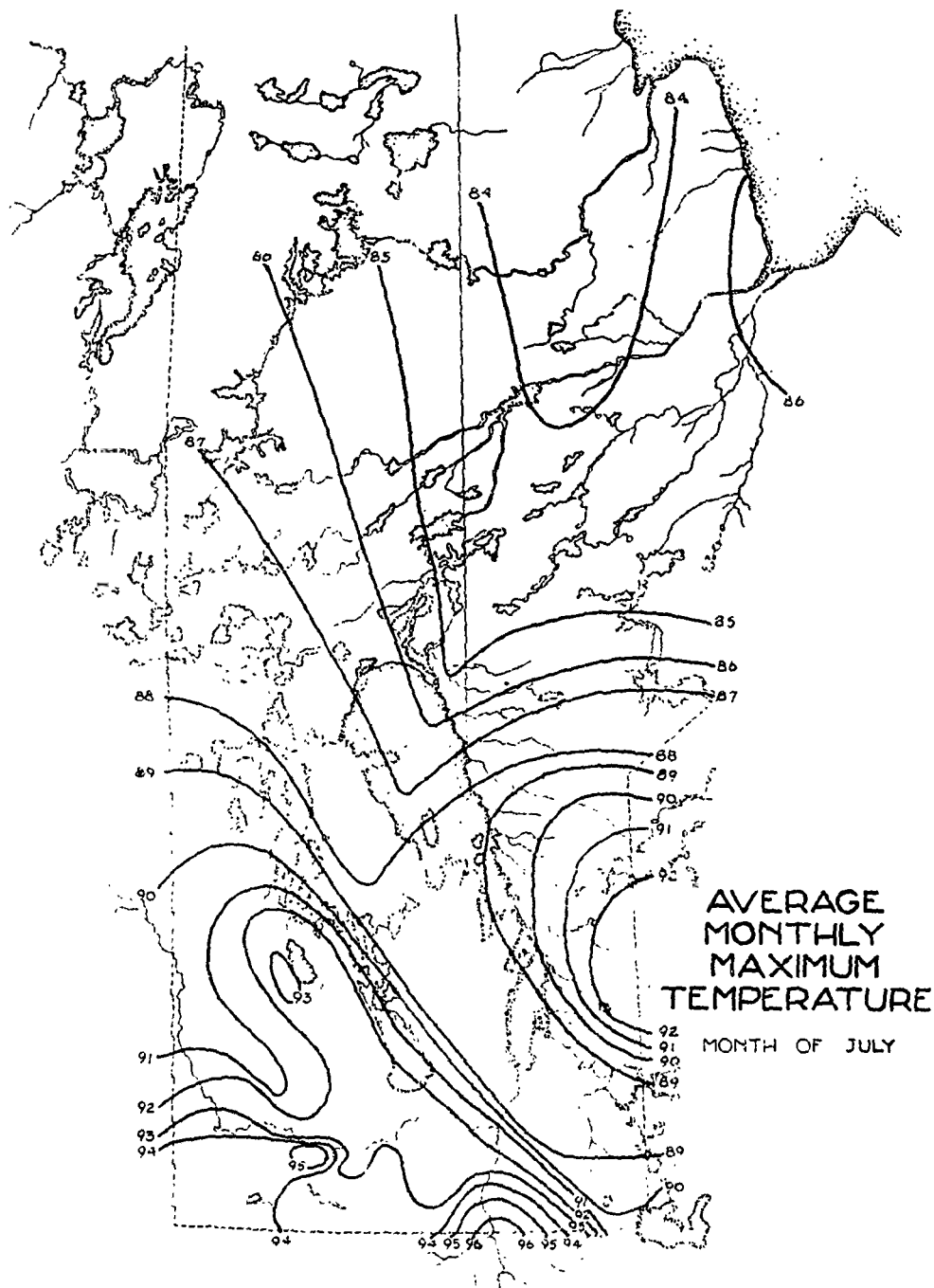
(4) In April the tendency of the Hudson Bay area to keep northern airmasses traversing it from warming at the surface, and the similar but smaller effect of the Great Lakes, combine to establish a NW-SE trend to the isotherms. 50F. to 60F. may be expected at least once in any April between the lakes and the bay, but south of the lakes one or two days at least will probably reach 70F. to 75F. Rarely 85F. to 90F. may occur in April in the far south but 60F. might be reached only once or twice in 50 years in the extreme north.



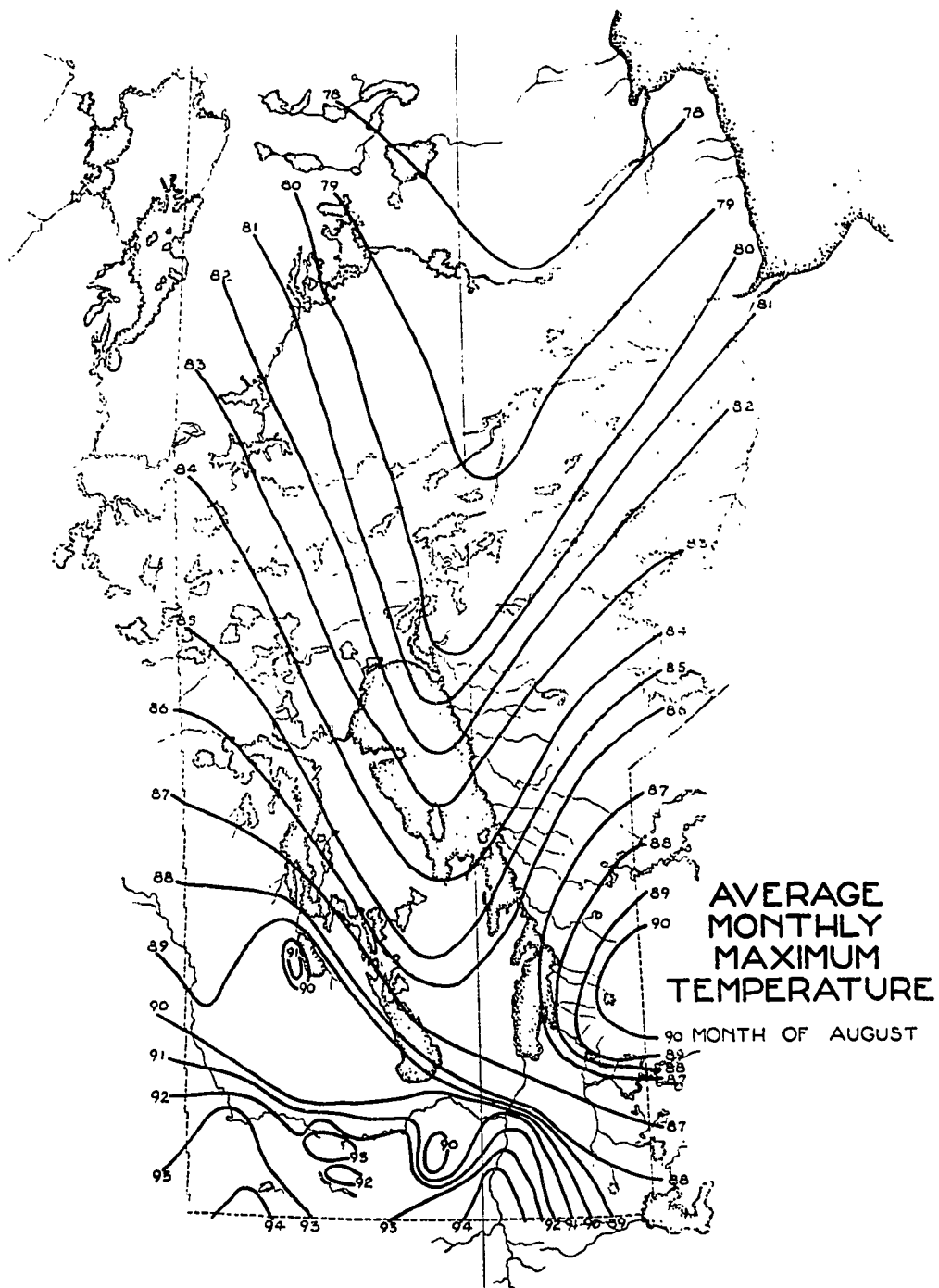
(5) Temperatures between 90F. and 100F. have been recorded on rare occasions in the southern region and even at Churchill 87F. has been reached. The highest temperature to be expected in May falls rapidly, however, from the interlake district to the shores of Hudson Bay.



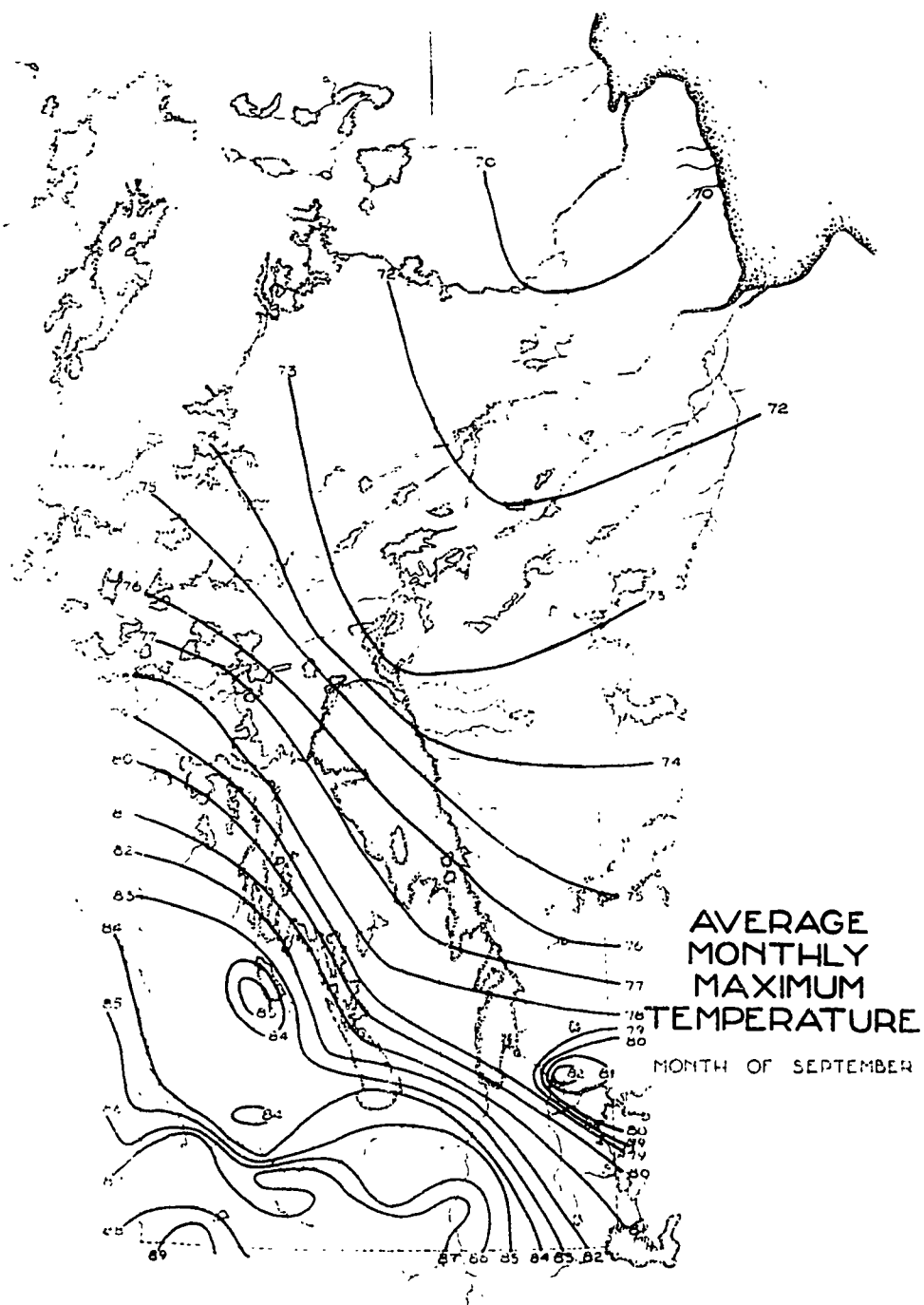
(6) In June the gradient of temperature flattens very noticeably over Manitoba. The great areas of the northwest are now warmed while the cold airmasses from the Arctic Archipelago tend to drift to the east across Hudson Bay without affecting northeastern Manitoba to the same extent as in the spring months. There is a range of about 25 degrees between the peaks of warmth to be expected at Churchill and in the Souris region but the difference is spread very uniformly across the interlake and northern regions. Temperatures exceeding 100F. may rarely occur in the southern regions but 90F. has been reached only once or twice in the whole period of record on the shores of Hudson Bay.



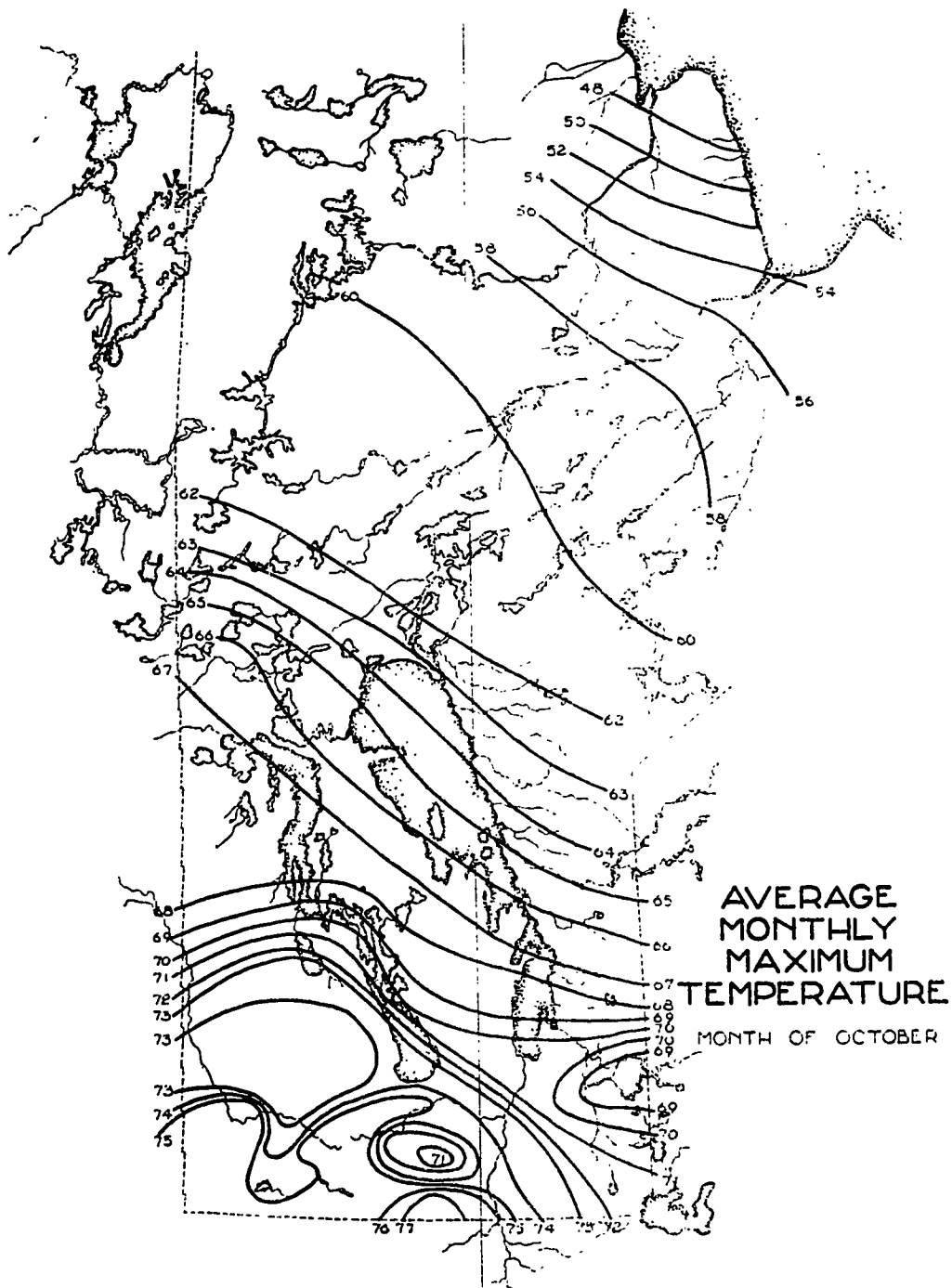
(7) In July there is strong heating at the ground on quiet, sunny days. Over bodies of water on calm days the lower strata of air do not reach such high temperatures as over land areas. Although turbulence is set up by the unequal heating with resultant mixing, the temperature-gradients remain steep in the vicinity of lakes. Mixing by upvalley and downvalley winds also occurs in the southwestern hilly region. There are not enough stations to determine with any accuracy the local variations in the southwest and far north during July.



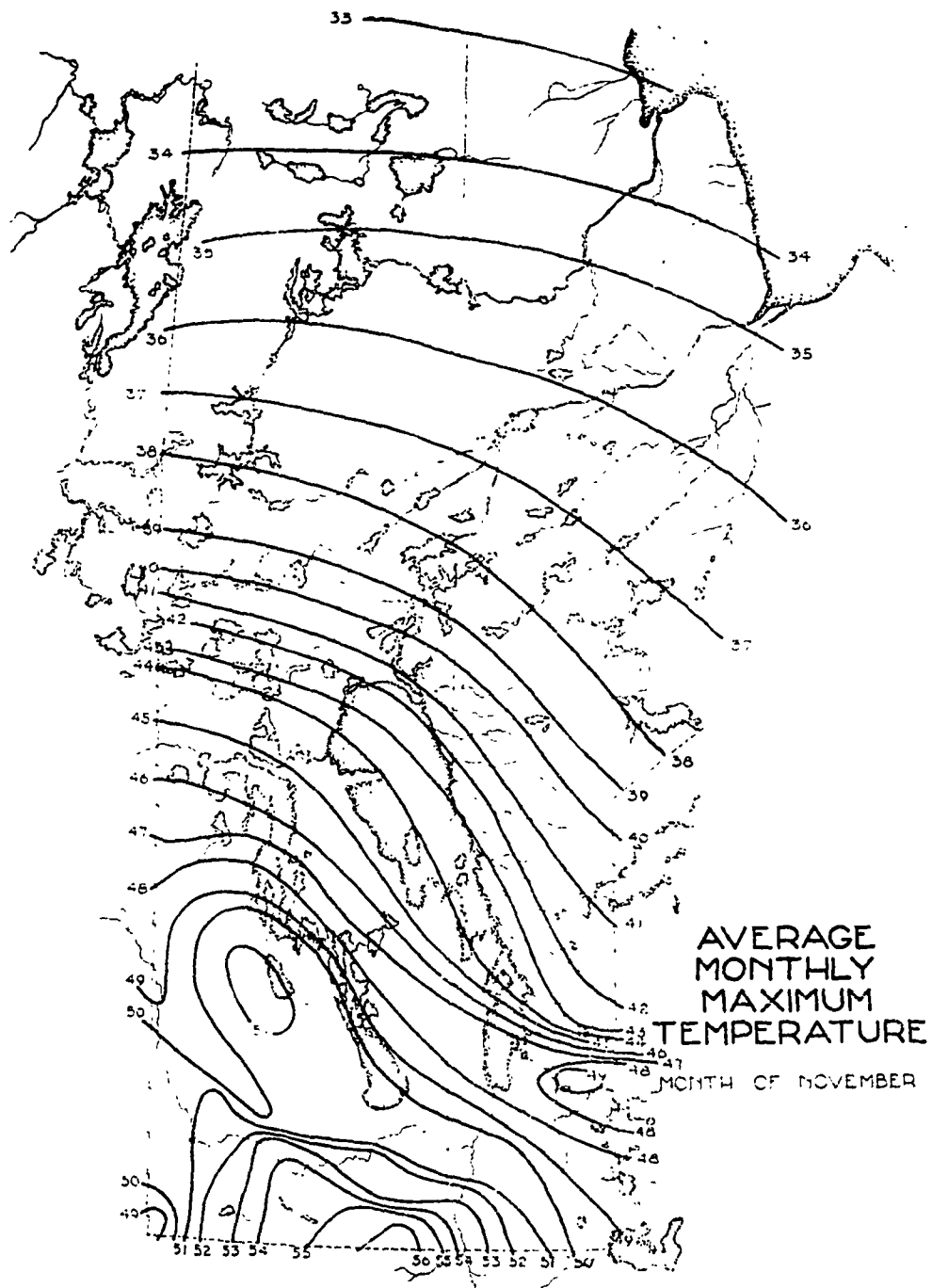
(8) In August conditions are much the same as in July except that in the far north the beginnings of winter cooling are becoming apparent.



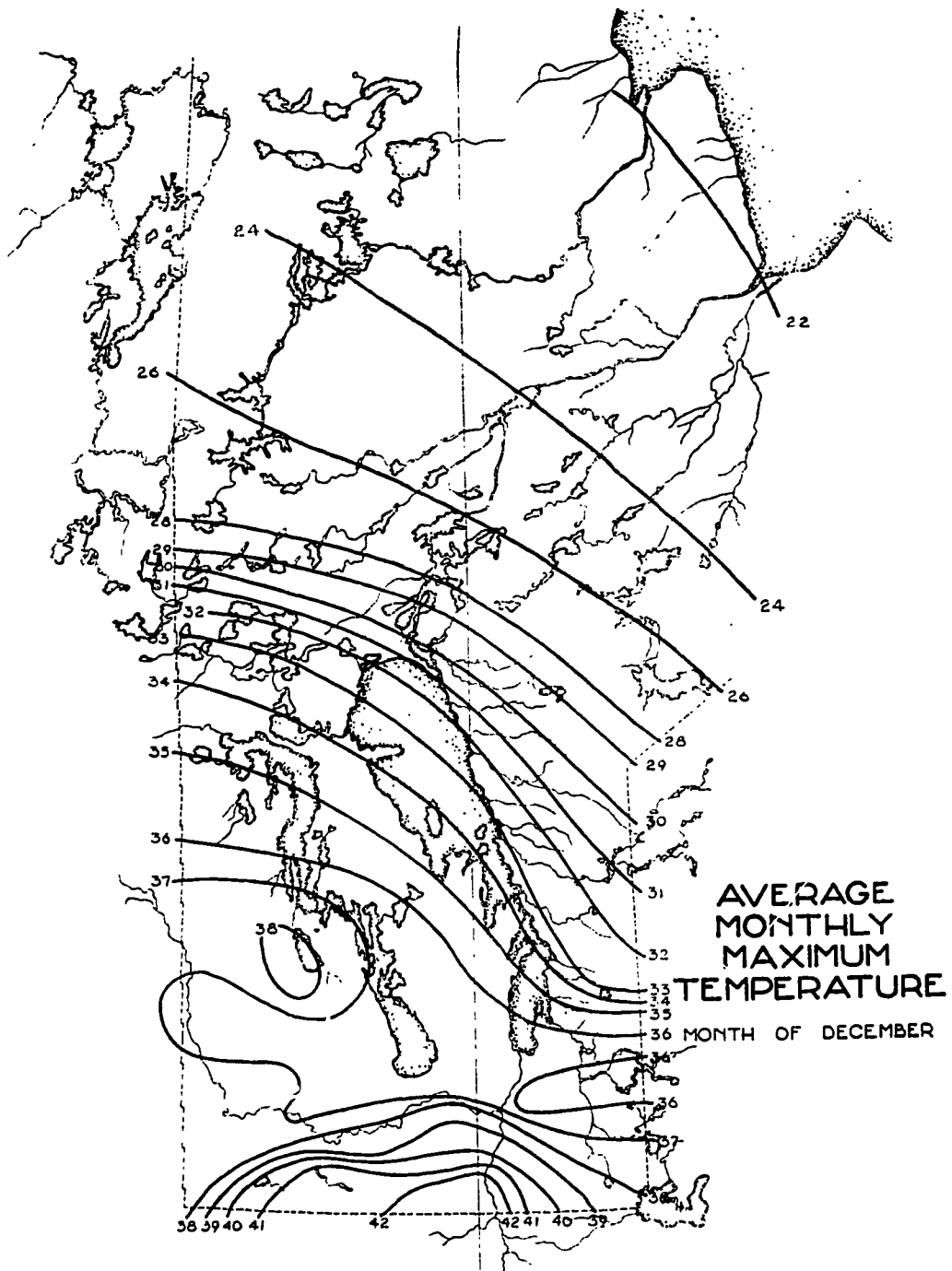
(9) In September the tendency to high afternoon temperatures has not decreased so much in the south as in the far north.



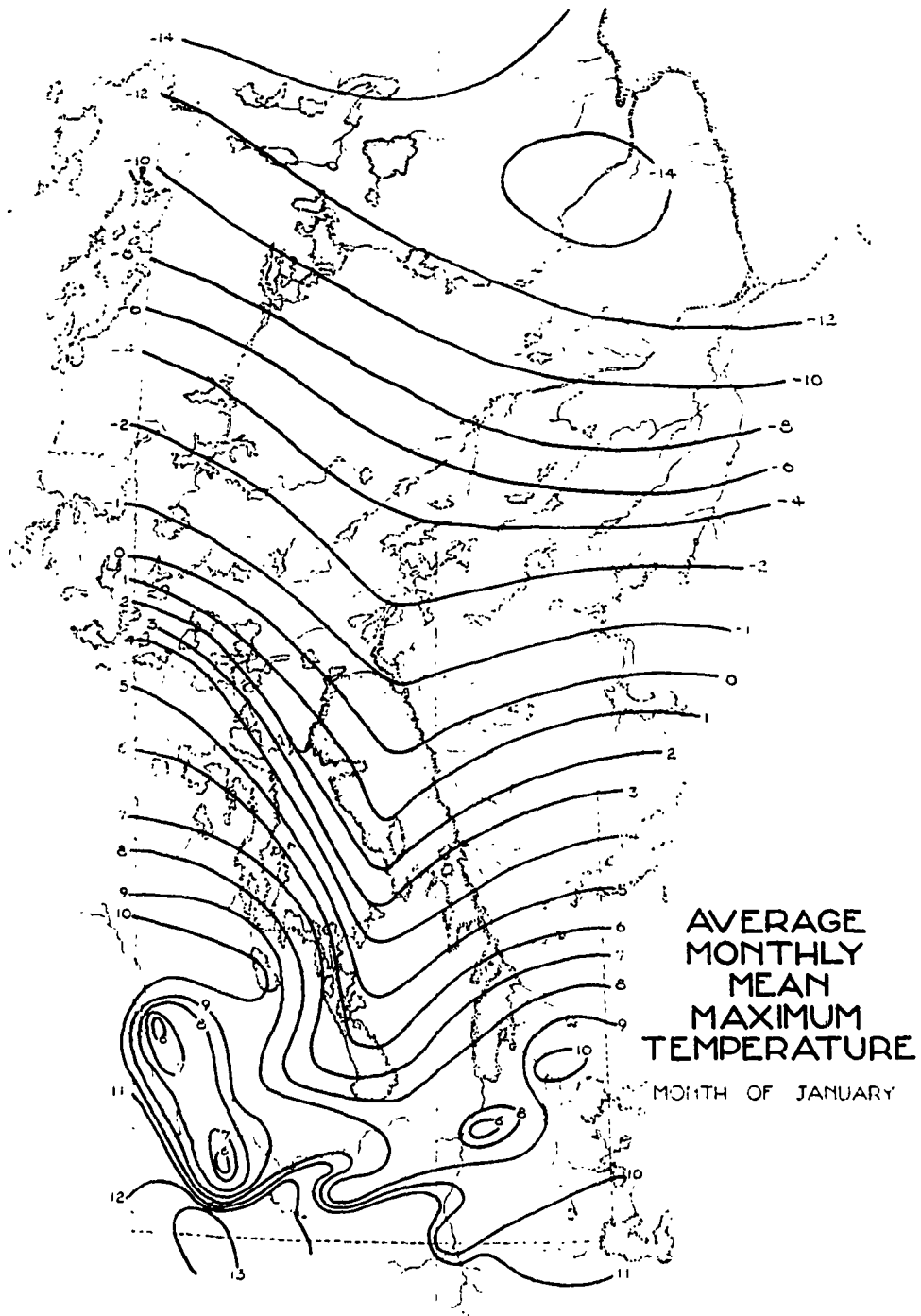
(10) In October there are some anomalies which are hard to explain except on the basis of unequal lengths of the period of observation. The higher maxima over unbroken land-areas in the south and the approach of winter in the far north are quite noticeable.



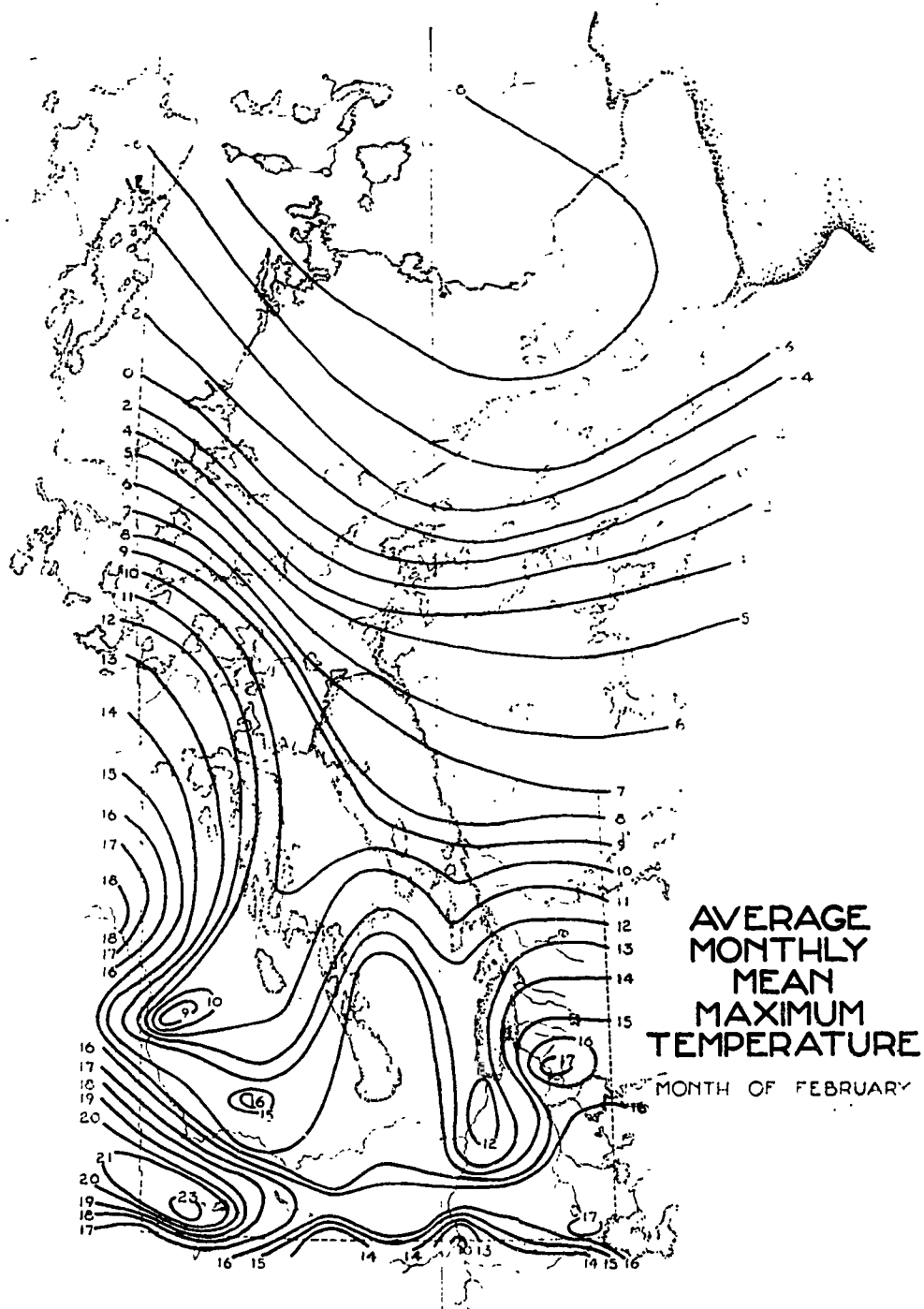
(11) In November northern Manitoba is very often under the influence of only slightly modified polar airmasses for several days at a time. Along the southern margin of such airmasses the warmer air from midcontinent is often drawn into low-pressure waves crossing southern Manitoba. The southern districts have, therefore, much greater probability of a few quite mild days.



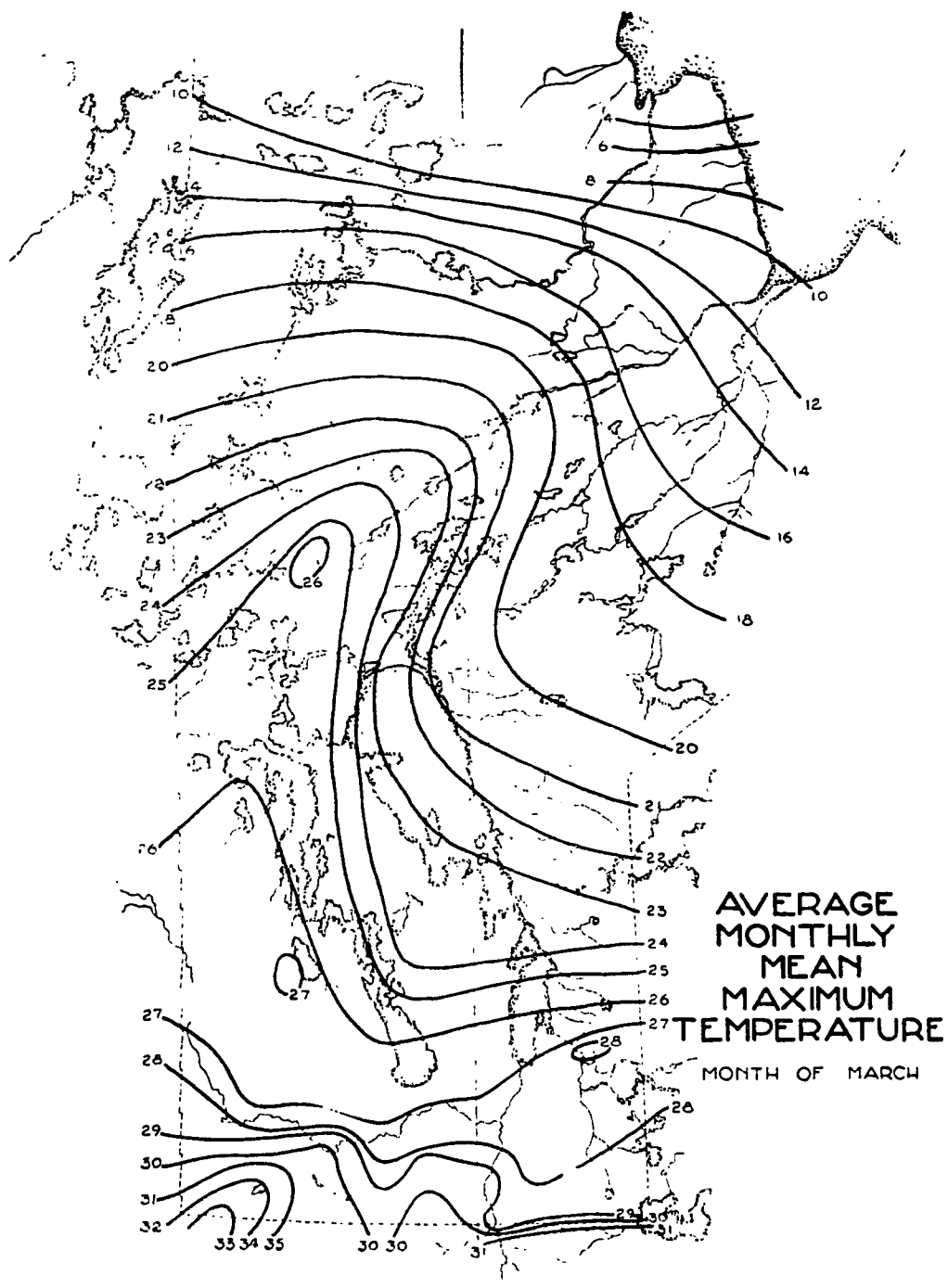
(12) In December nearly steady cold over the northern regions west of Hudson Bay and frequent interaction between relatively warm airmasses and the northern cold waves combine to produce steep temperature-gradients in the south and flat gradients in the far north.



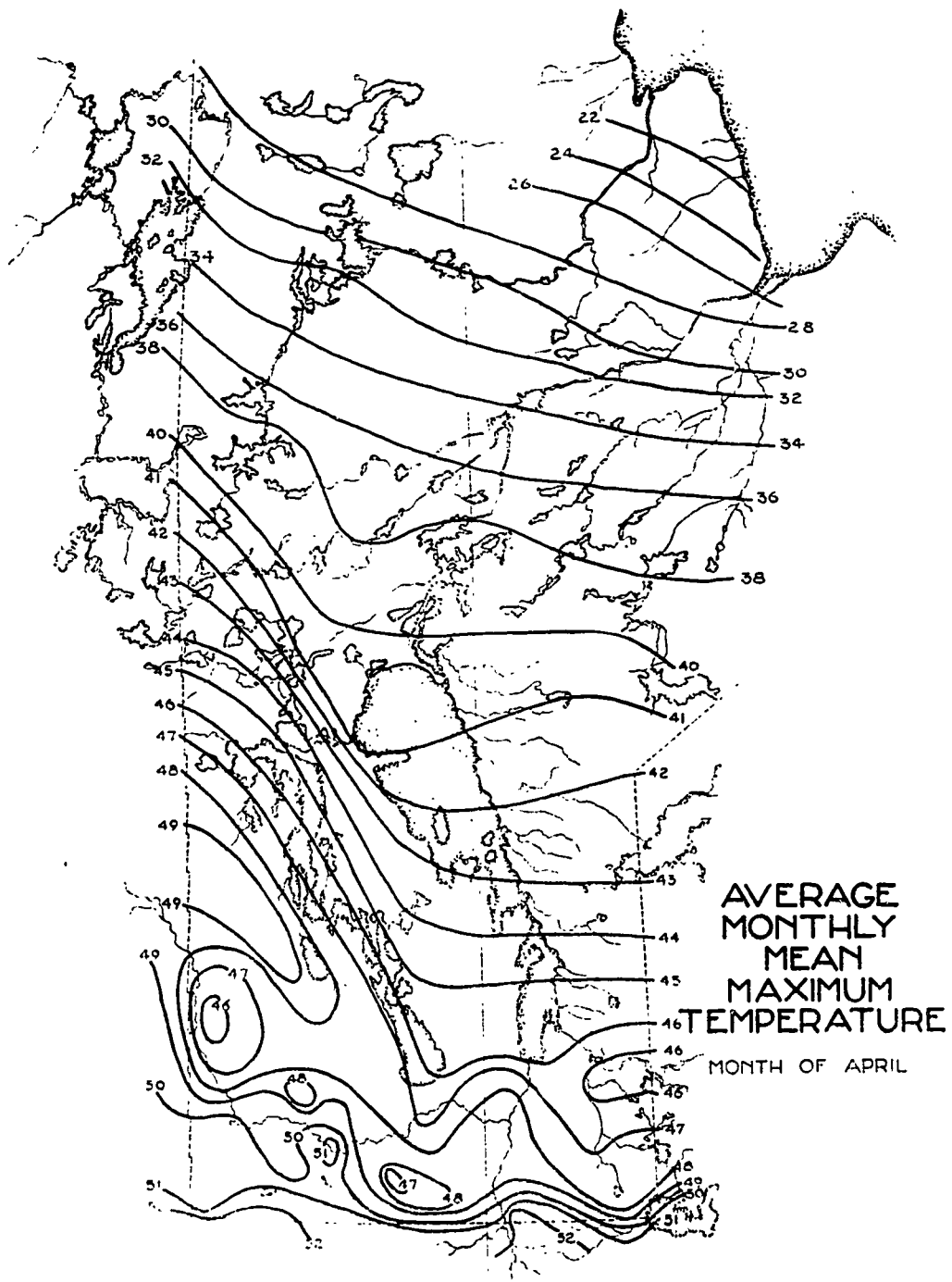
(13) This map differs from map No. (1) because the highest temperature of every January day during the period of record has been utilized to form the isotherms. Thus, on map (1) a record of 20 years at a given place will yield only 20 monthly extremes while on map (13) the same place will have (20x31) or 620 daily highest temperatures to be averaged. The comparative cold of the hilly region of the southwest becomes apparent when every day's temperature is utilized. There are some peculiarities in the figures which no doubt will disappear from the map when records cover a longer period.



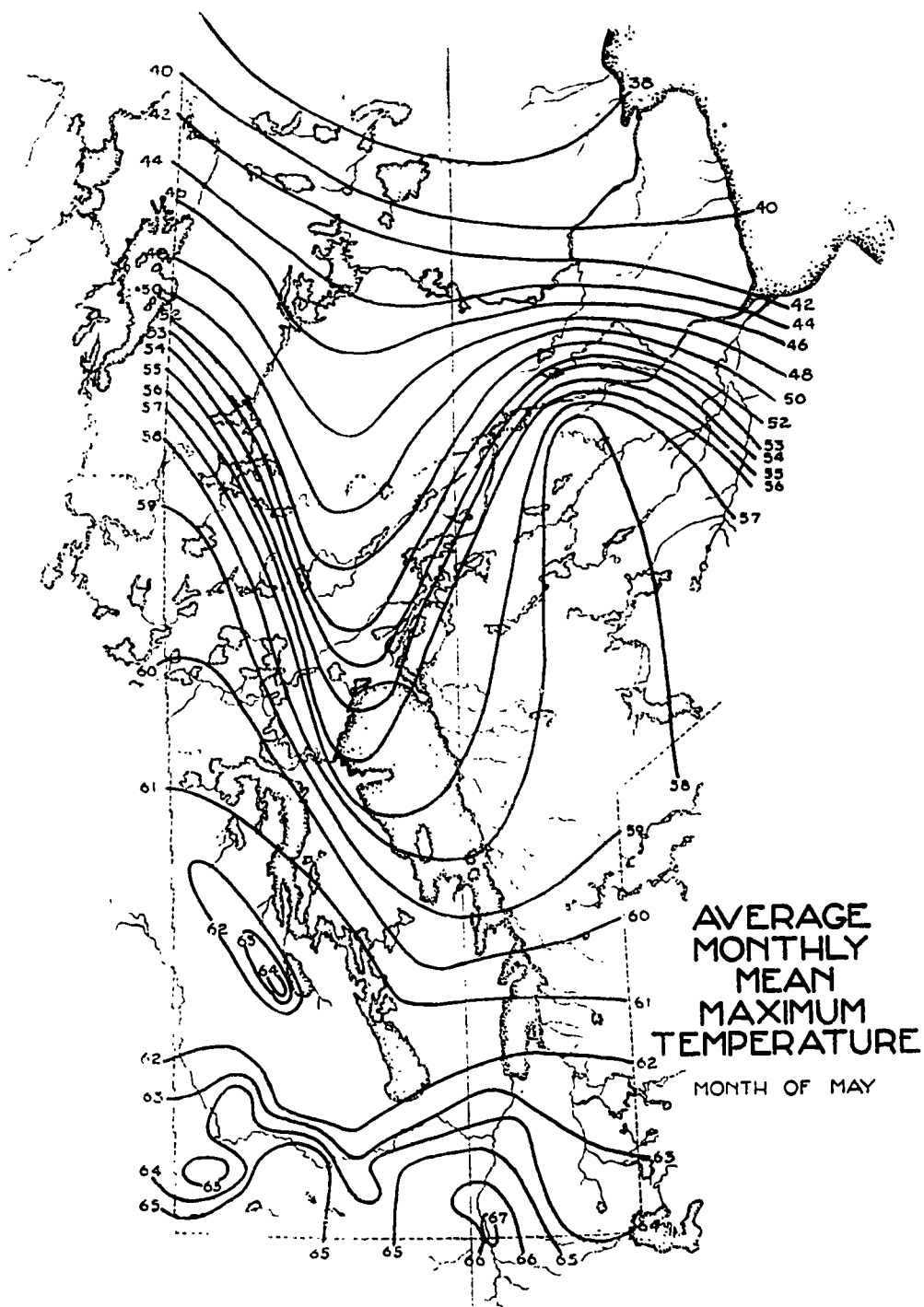
(14) In February the northern margin of the interlake region has gained about 6 or 7 degrees in daytime temperature over daytime temperature in January. The southwestern portion of the lake region has gained very little. This seems to be caused by the tendency for cold air to be drawn south in the rear of low-pressure waves crossing the Missouri valley and adjoining regions. The comparative daytime warmth of the extreme southwest is supported by some observations in the adjoining region of Saskatchewan.



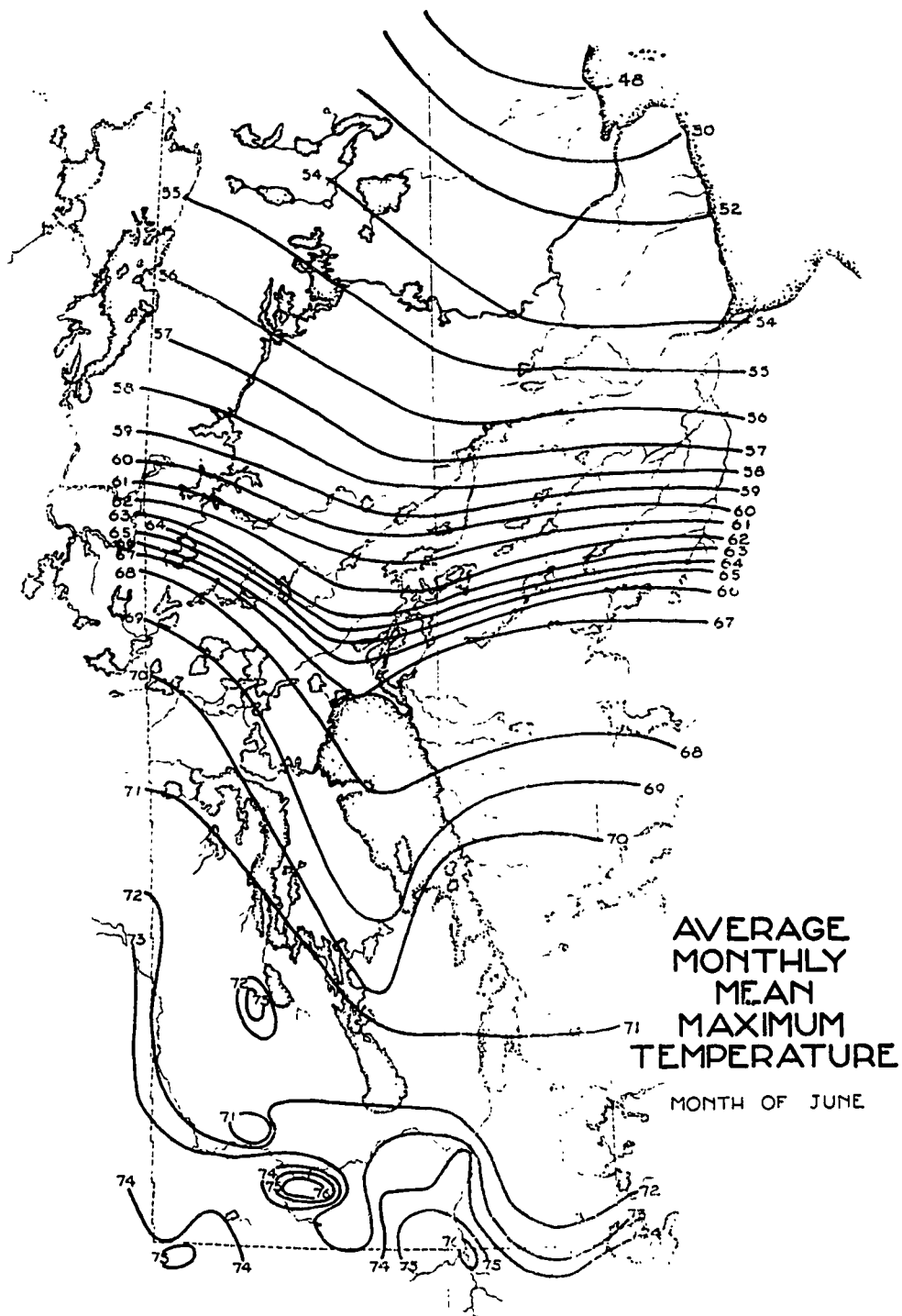
(15) In March on the average only the extreme southwestern districts generally reach the freezing-point each day. In the north the month is still definitely of a wintry character.



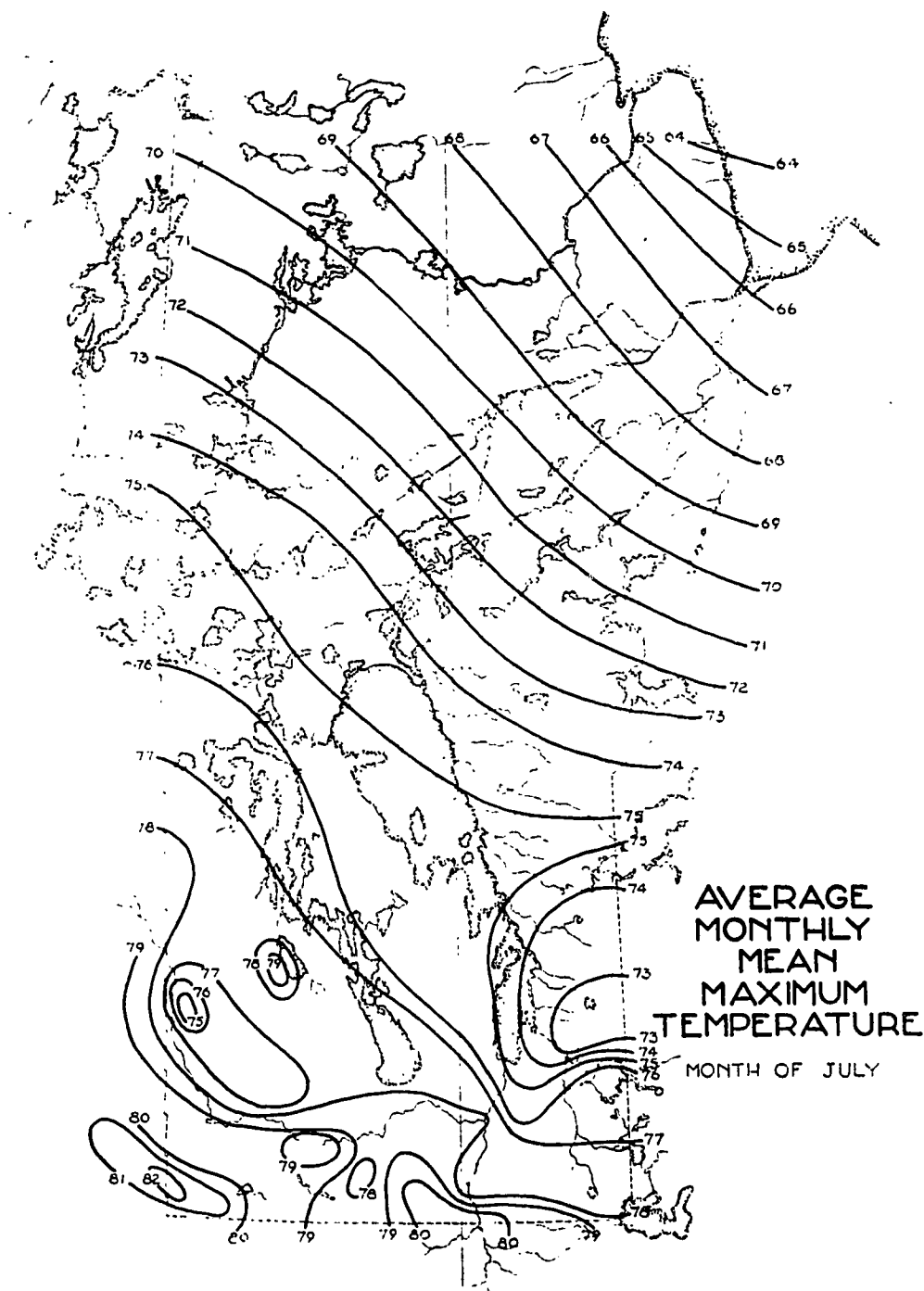
(16) In April the daytime temperatures average high enough for growth in the southern region but if a mean daily highest temperature of 43F. is taken as a criterion of growing weather, we see that spring has scarcely reached the interlake region. April is still a winter month north of the lakes.



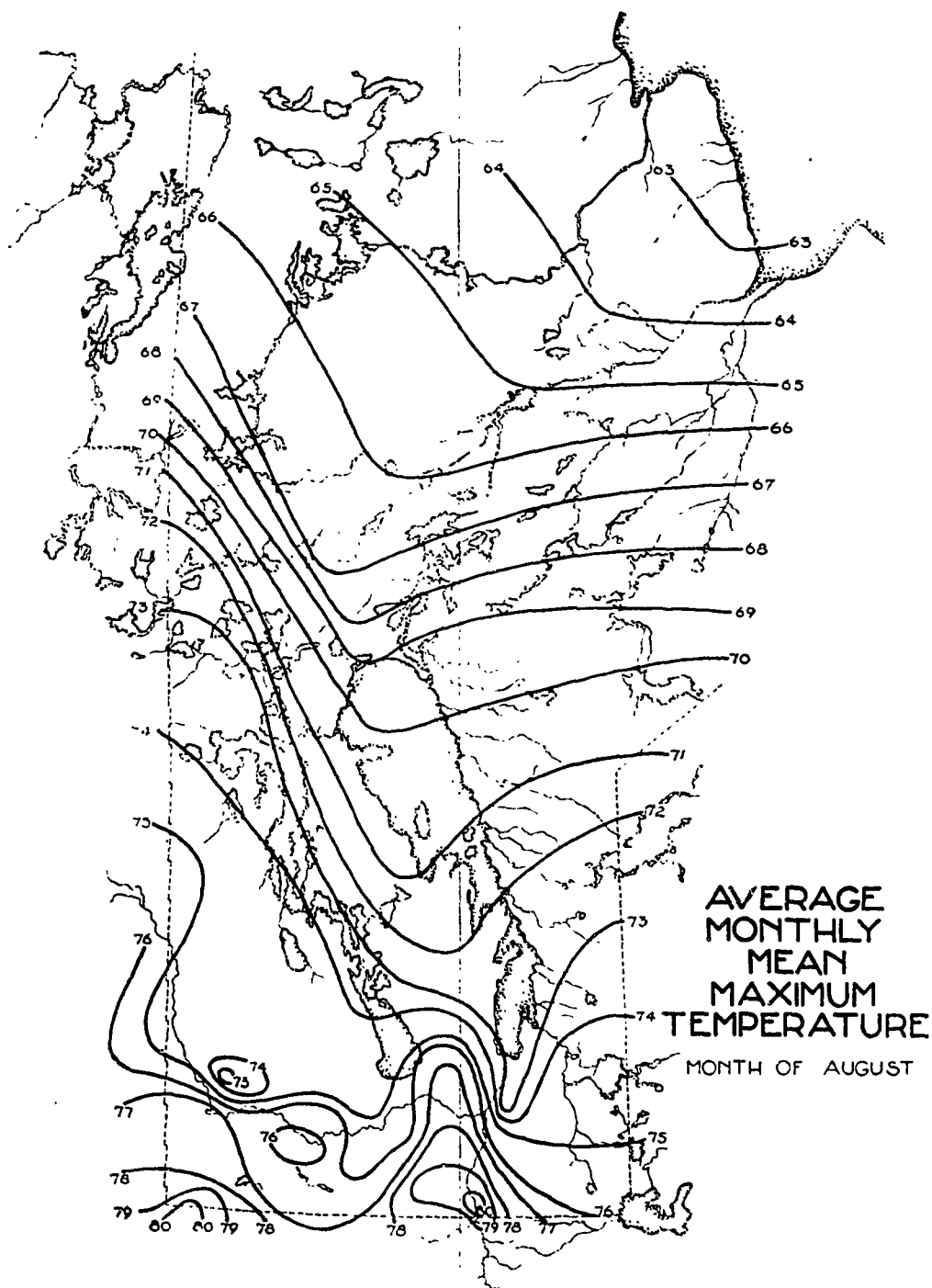
(17) In May temperatures average high enough for growth as far north as Port Nelson on the east and a little further north in the west. The upper part of the lake region is not warming as rapidly as the regions immediately east and west.



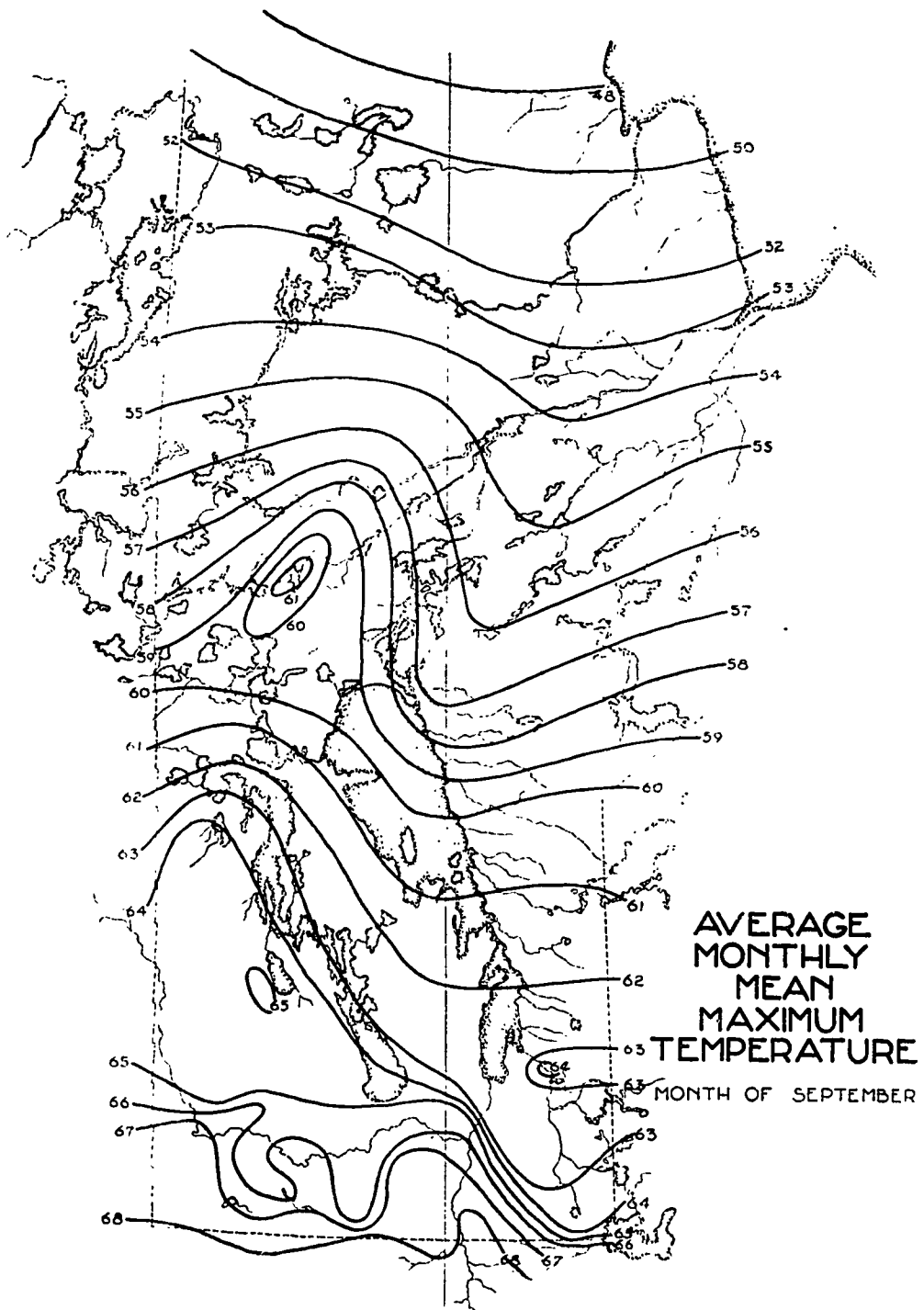
(18) In June if we take a mean daily highest temperature of 70°F. as a criterion of summer, we see that summer is established as far north as the central portion of the interlake region. Daytime temperatures are high enough for vigorous growth of grasses over the whole of the province.



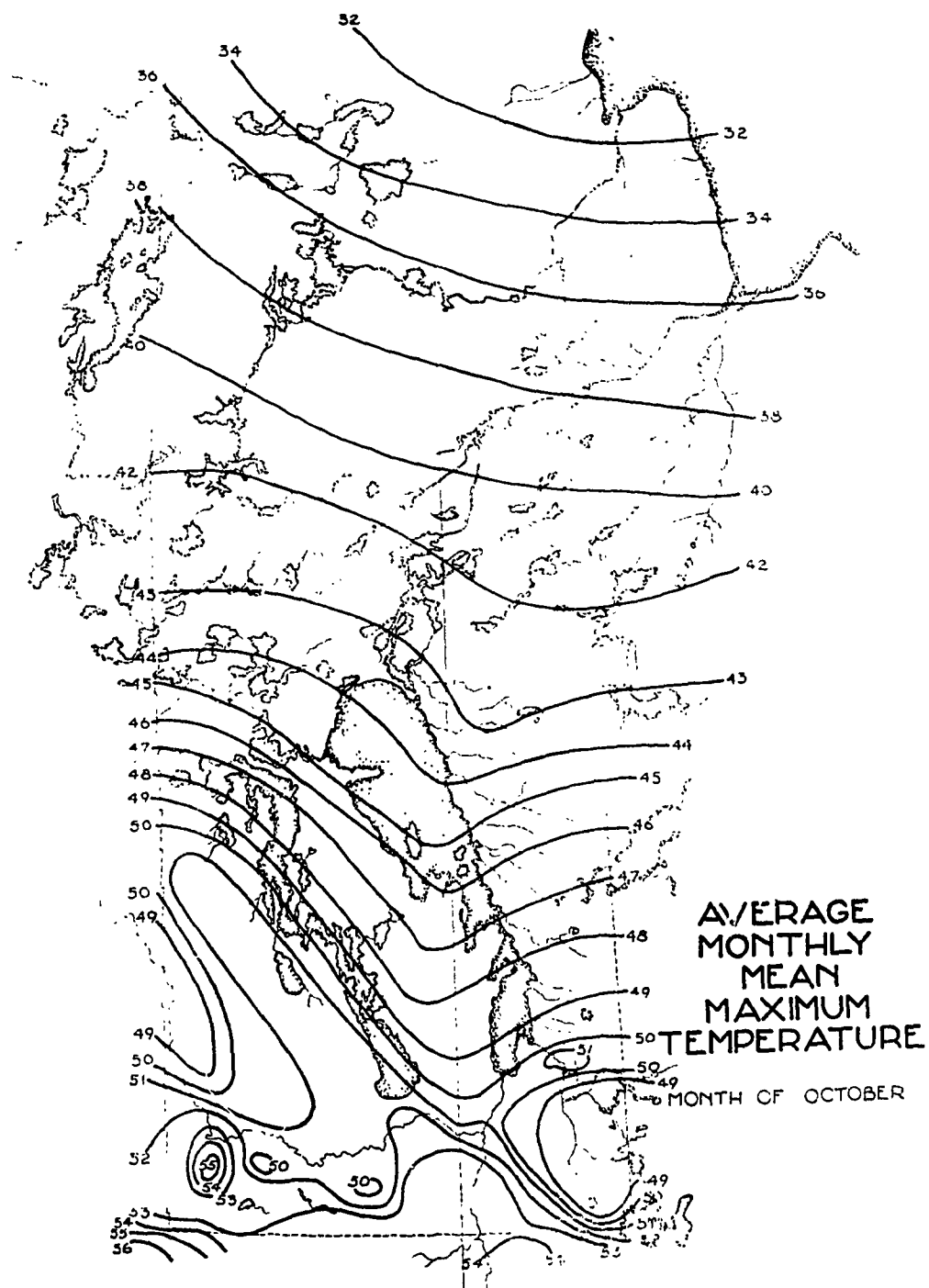
(19) In July summer extends well beyond Reindeer Lake on the Saskatchewan plains but the lower reaches of the Nelson and Churchill rivers are so often affected by cool airmasses from the Hudson Bay region that their average temperature falls noticeably below summer warmth. In the far south spells of great heat reaching maxima of 95F. to 115F. may occur in July. Therefore, a week or ten days with mean daily maxima ten or fifteen degrees above normal can occur in some years.



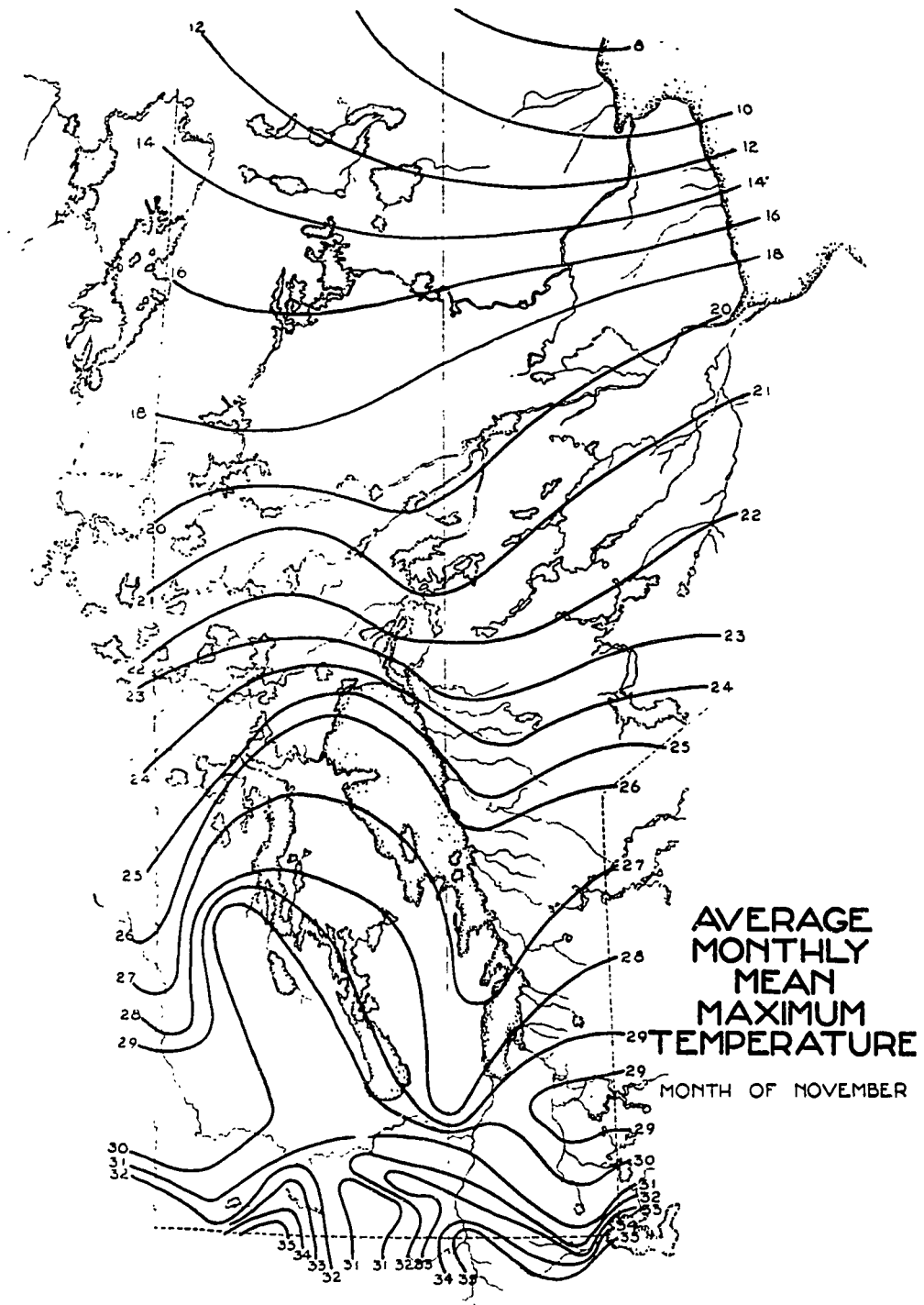
(20) In August, using as our criterion of summer a mean daily maximum of 70F., we see that summer ends about the middle of the month on the average at the northern end of Lake Winnipeg. The extreme northwestern portion of the province is cooling more slowly than the northeast. Midsummer heat is still to be expected in the far south. Heating engineers have a formula which calls for artificial heating when the mean temperature of the 24 hours falls below 65F. On the lower Nelson river we see that even the warmest hour of daylight is cooler than 65F.



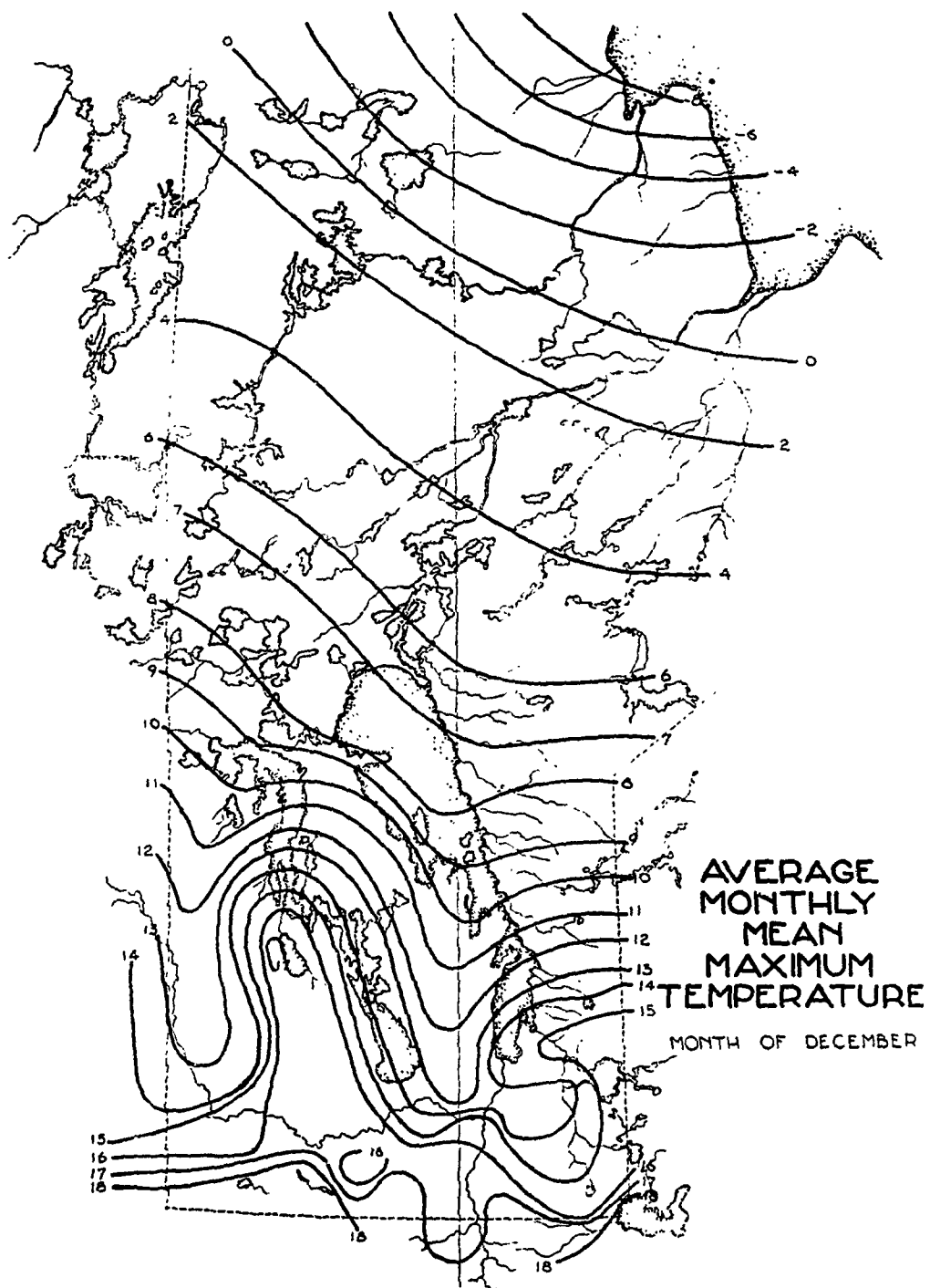
(21) By our criterion of a mean daily maximum of 70F. we find that on the average summer ended a little before the 15th of September. Over the whole of the province temperatures are still high enough for growth of all plants which have not been killed by the occasional early frosts.



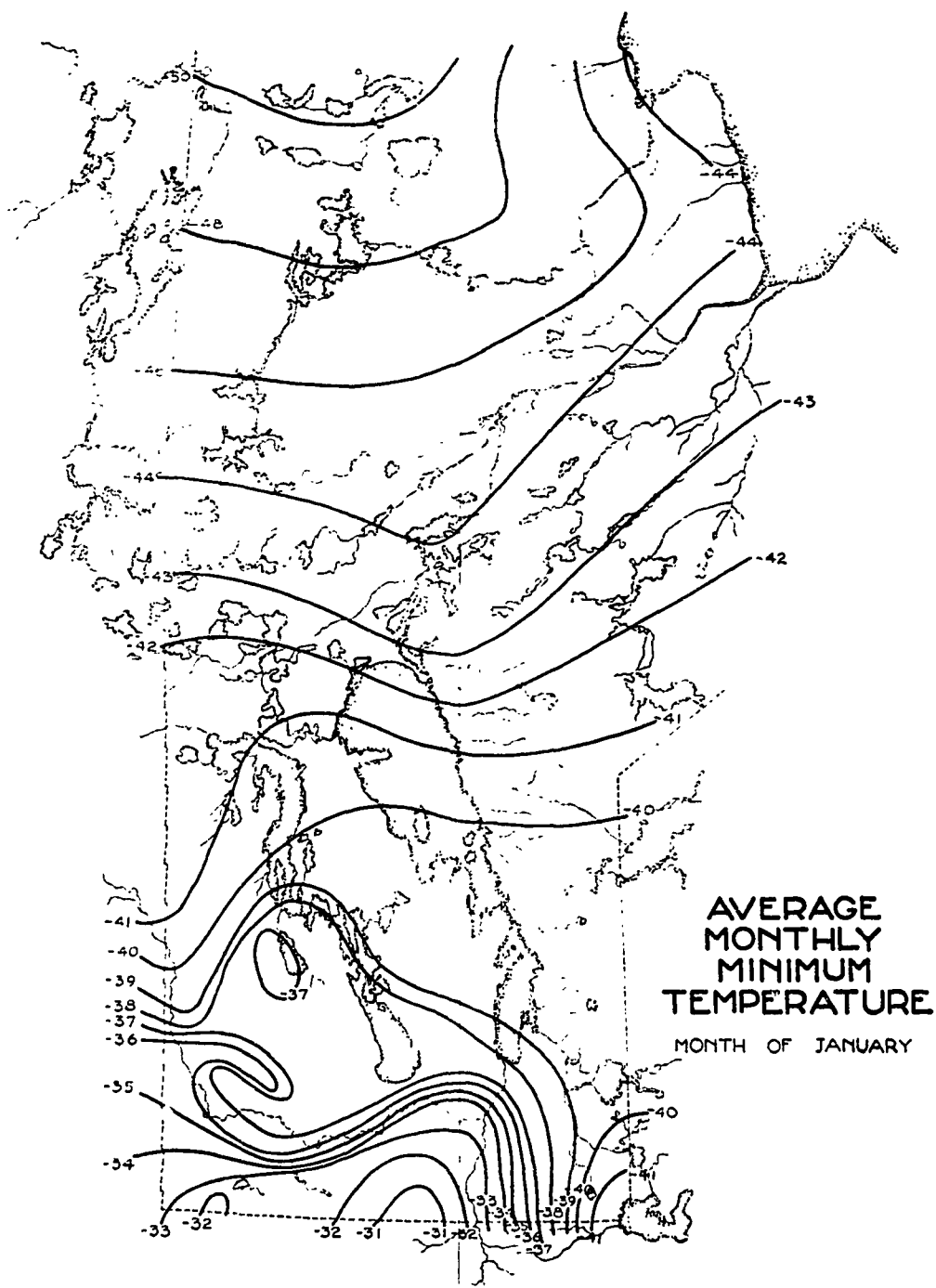
(22) In October the average daily highest temperature of 43F. is found immediately north of the lakes. On the average every day after the 15th of October will fail to reach this temperature even at the warmest hour. Therefore, cessation of all growth may be expected north of the lakes after the middle of October.



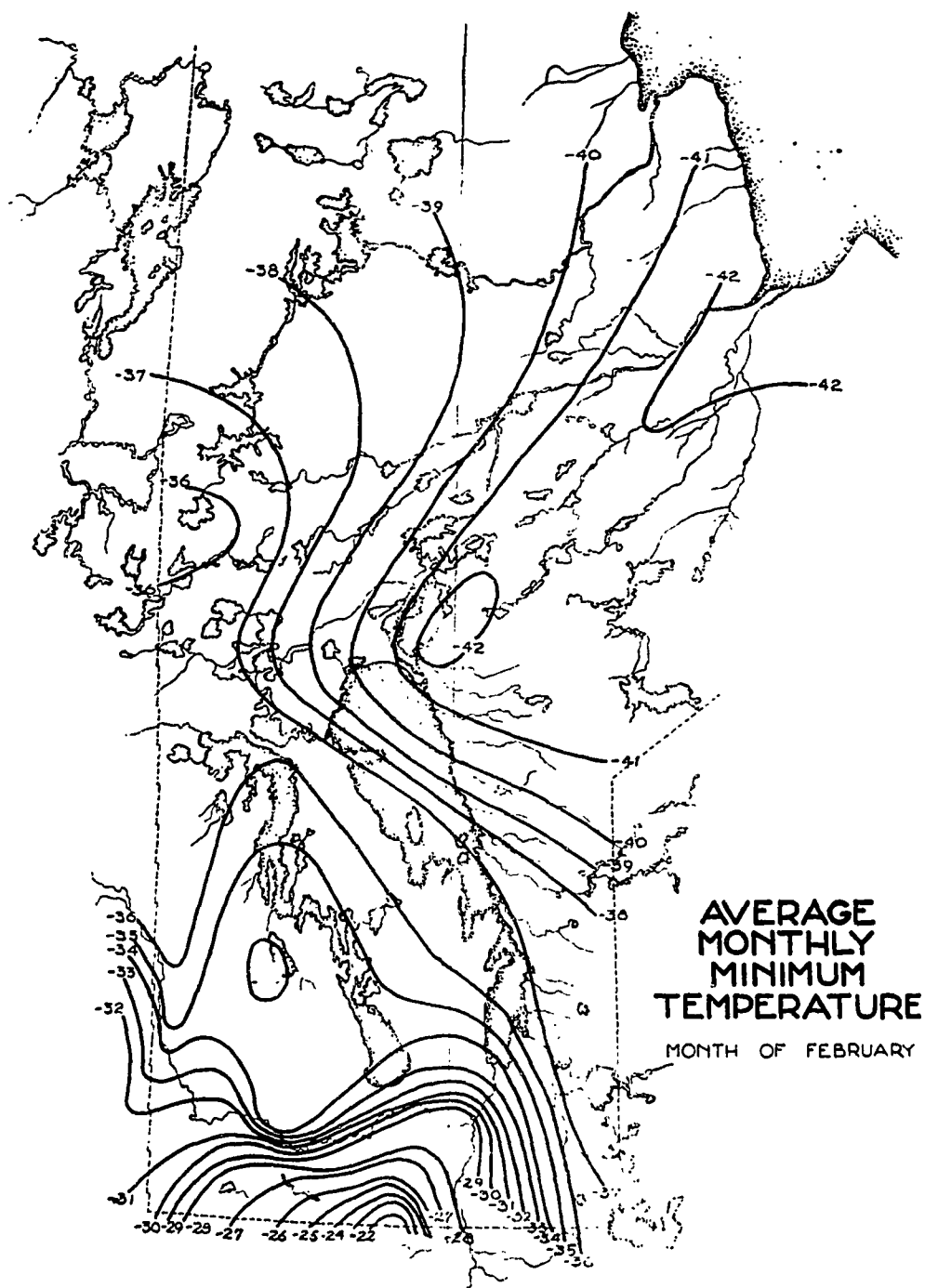
(23) In November after the middle of the month no place in southern Manitoba need expect that the temperature of every day will surely rise above the freezing point. However, referring to map No. 11, we see that an occasional very mild day with temperatures of 50F. to 55F. may be expected to occur. In the northern region we now have definitely winter conditions with temperatures below freezing throughout the 24 hours, except for an occasional extraordinarily mild day.



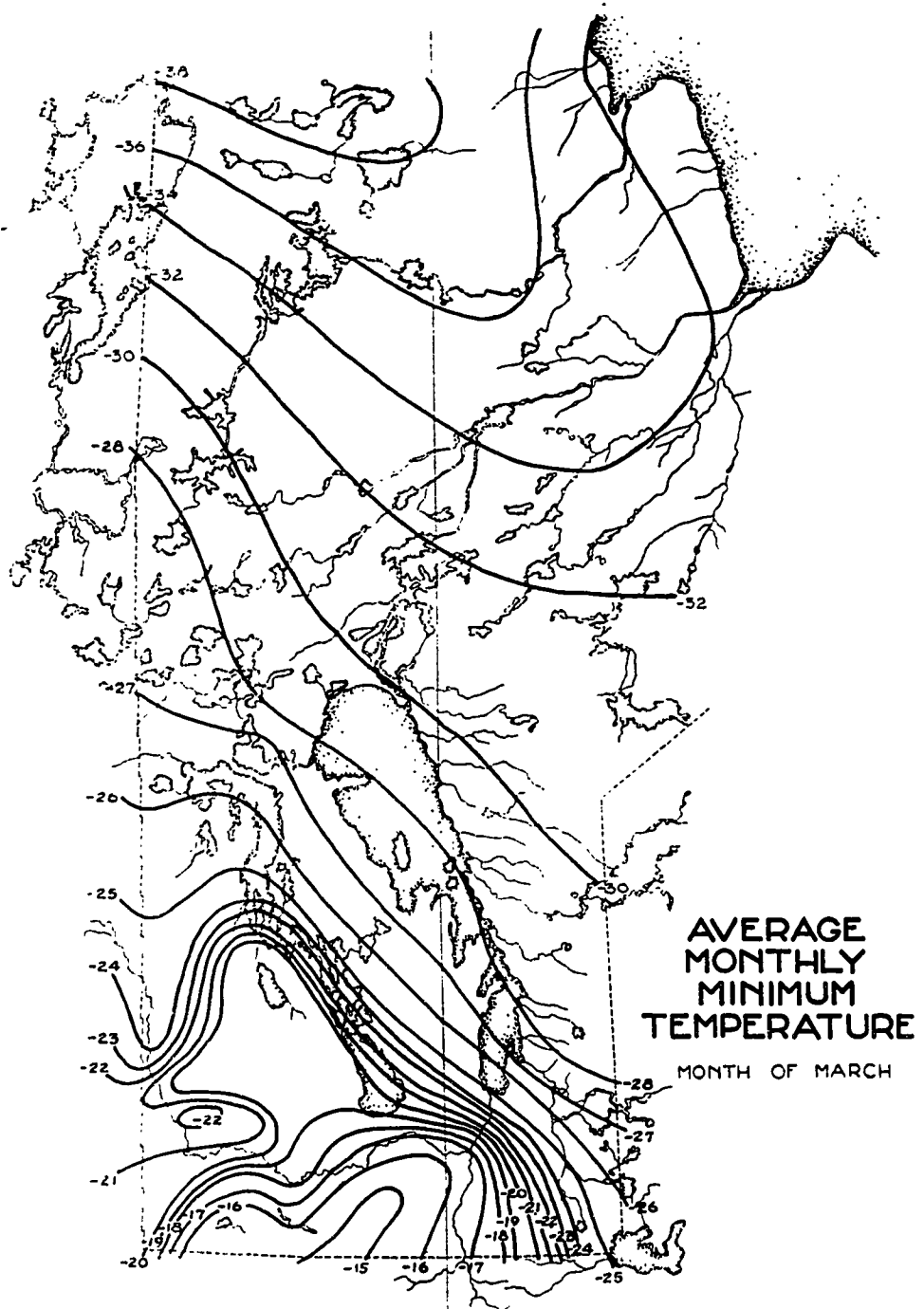
(24) In December the warmest hour of the day need not be expected to rise above zero in the region of the lower Churchill and Nelson rivers. The isotherms suggest that very cold air has two favored avenues of approach to southern Manitoba, viz., from the Hudson Bay region and from the plains of northern Saskatchewan.



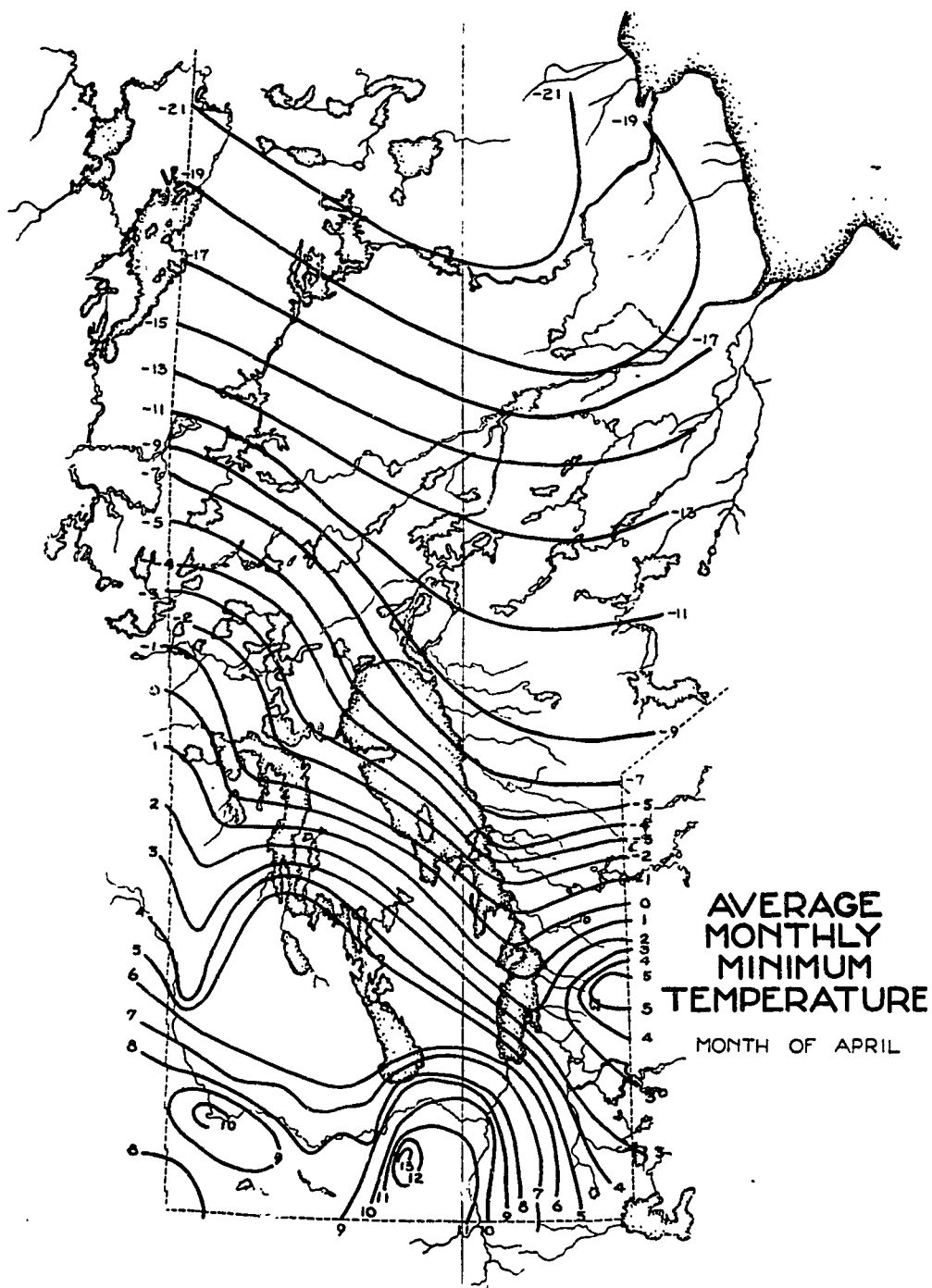
(25) On maps 25 to 36 will be found the very lowest temperature which ordinarily may be expected to occur at least once in any calendar-month. In January, although a temperature of 50F. or more below zero has been reached at a few points in southern Manitoba in one or two years since records began, one need expect nothing more severe than about 35F. below from the Red River westward to the Saskatchewan boundary. Very severe dips occur in the extreme southeast while in the far northwest at least one cold wave will probably reach a severity of -45F. to -50F.



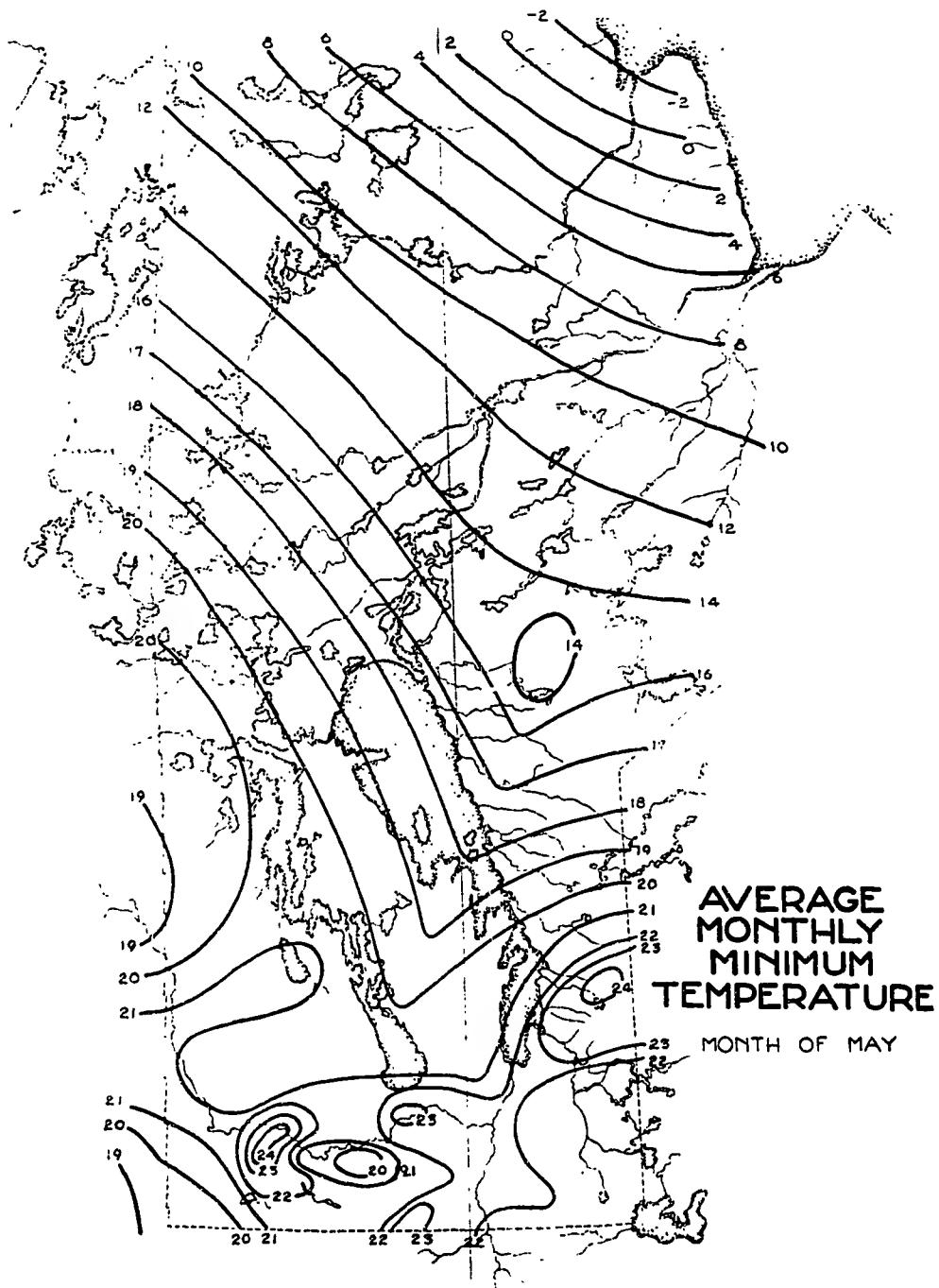
(26) Februaries with extremely low temperatures have not been as numerous as exceptional Januaries. This is most noticeable in the extreme south where the extreme lowest temperature to be expected lies between -20°F. and -30°F. In the northeast there is little improvement over January.



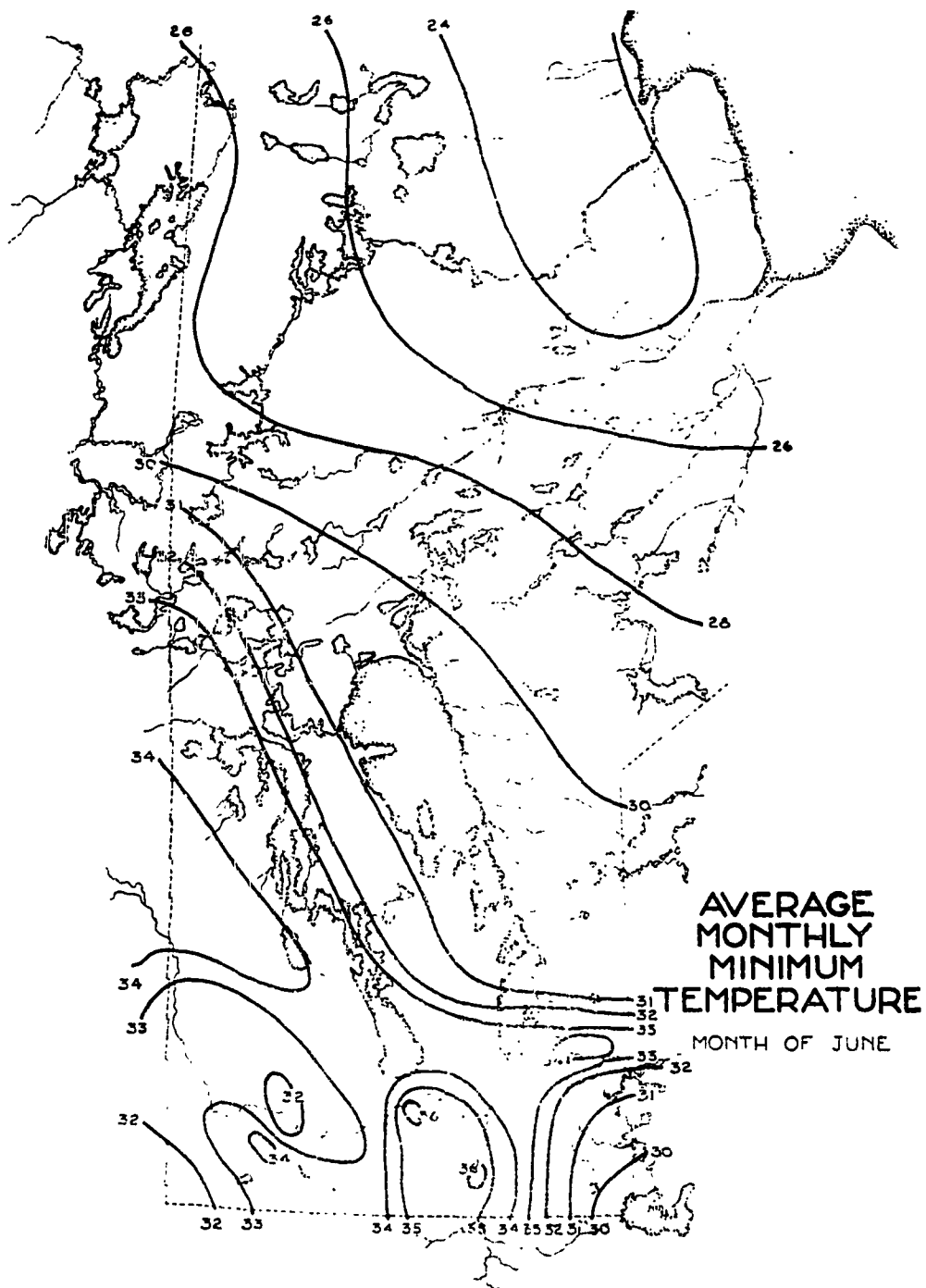
(27) In March the extreme cold dip of the month may be expected to be about 7 to 10 degrees less severe than in February over the greatest part of the province. In the extreme northwest, however, extremely cold continental airmasses which have not undergone much modification while passing south-eastward over the sub-arctic regions may be expected to bring at least one wave as cold as any in February.



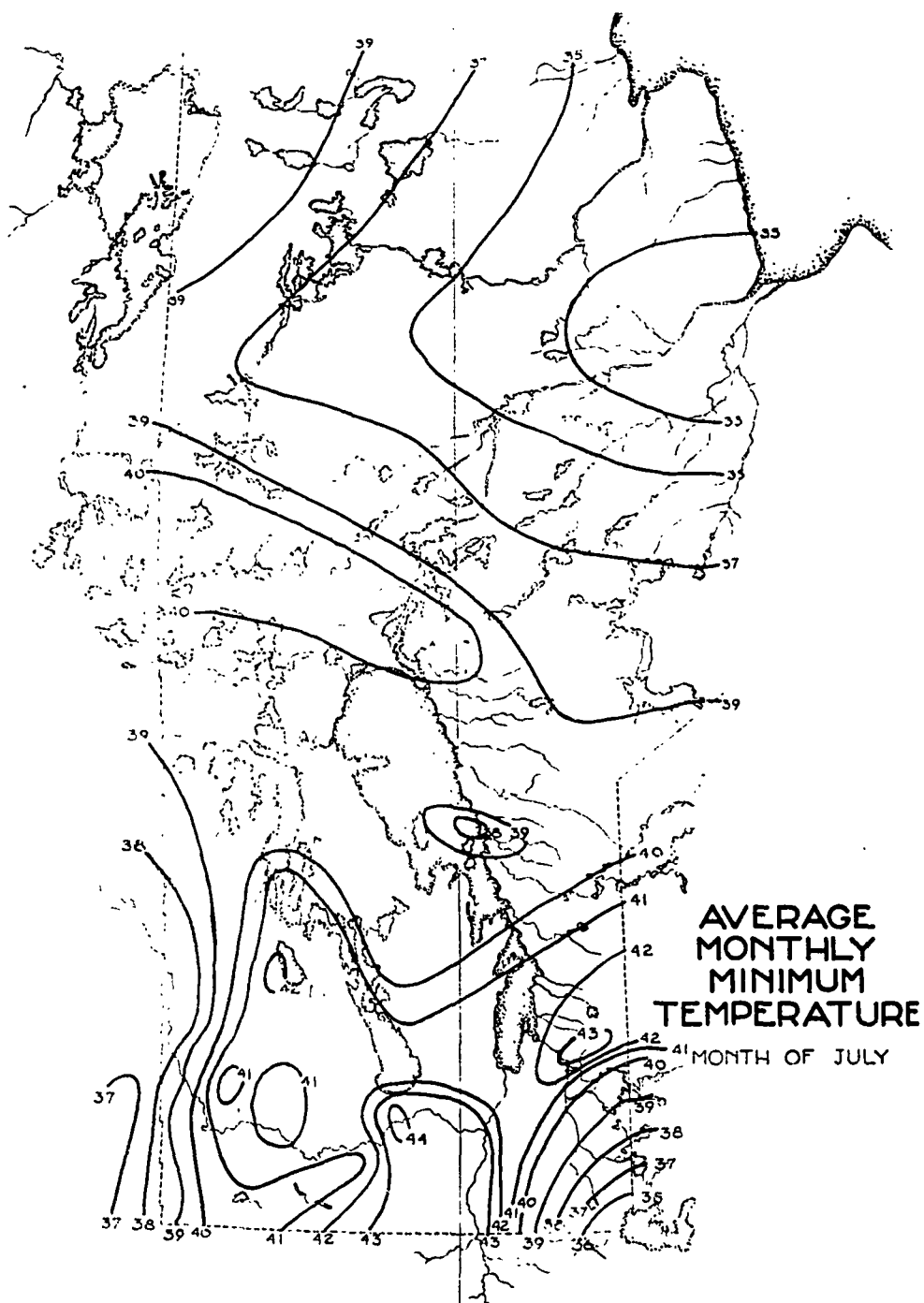
(28) In April the most extreme cold wave will likely be about 25F. higher in temperature than the worst to be expected in March in the south. In the extreme north the gain is generally less, about 15F.



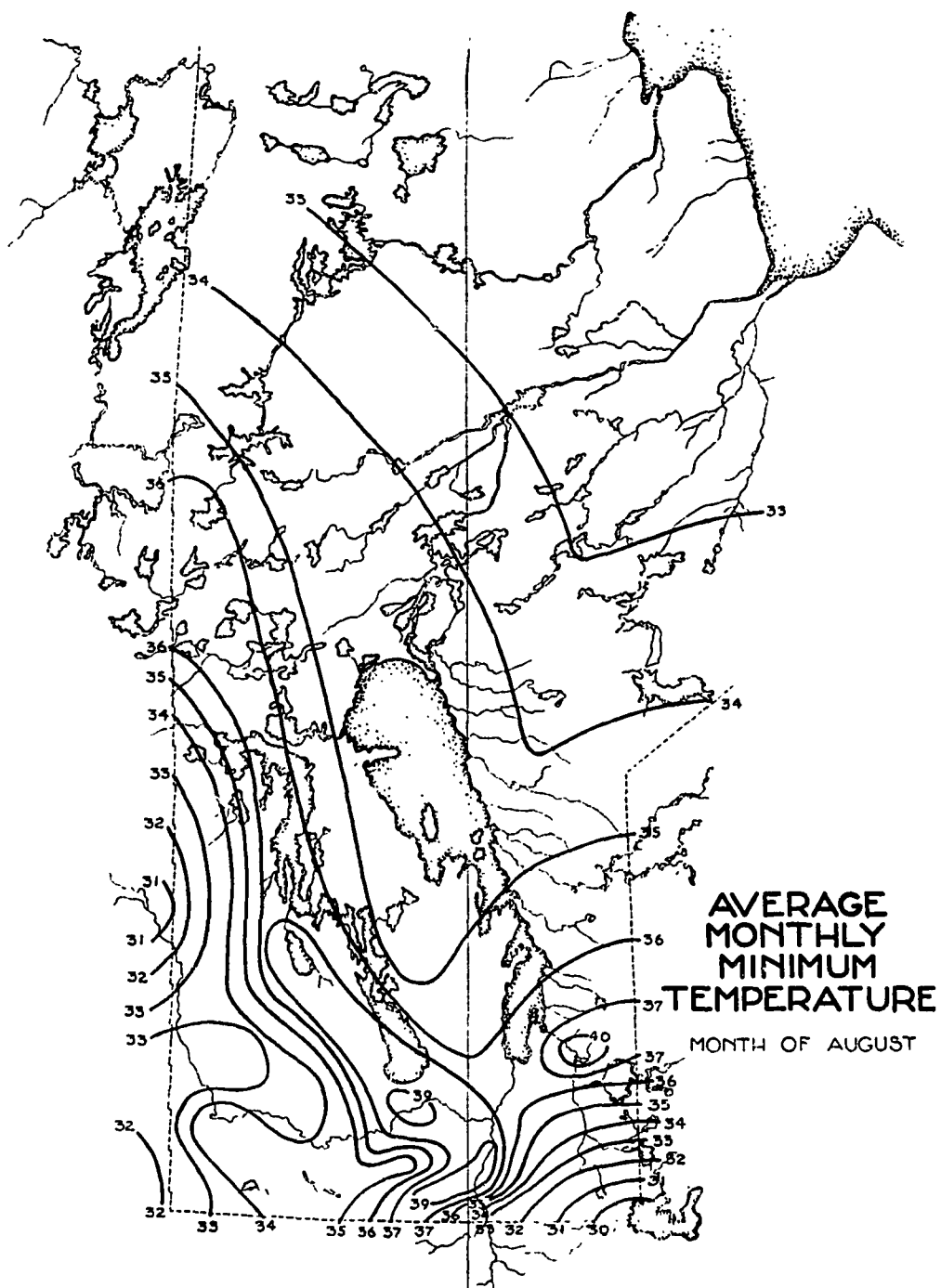
(29) In May the improvement in freedom from severely cold spells amounts to about 10F., or slightly more, over all the south and to about 15F. in the southeast. In the far northwest the gain is 20F. to 30F. but in the far northeast there is slightly more lag.



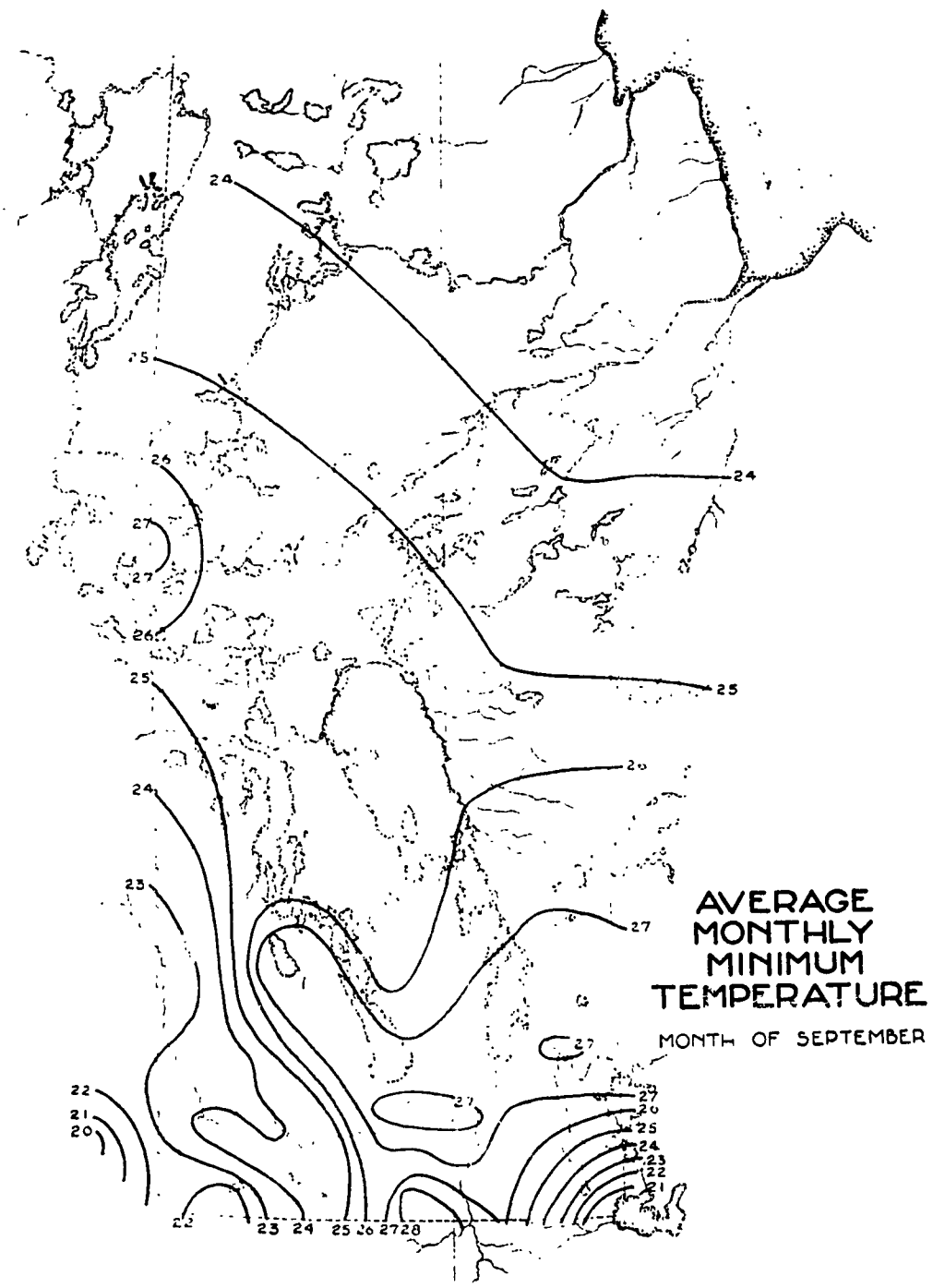
(30) In June there are some parts of the south where at least one day of frost or near-frost must be expected. Beyond the interlake region really sharp frosts must be expected, particularly in the first week of June.



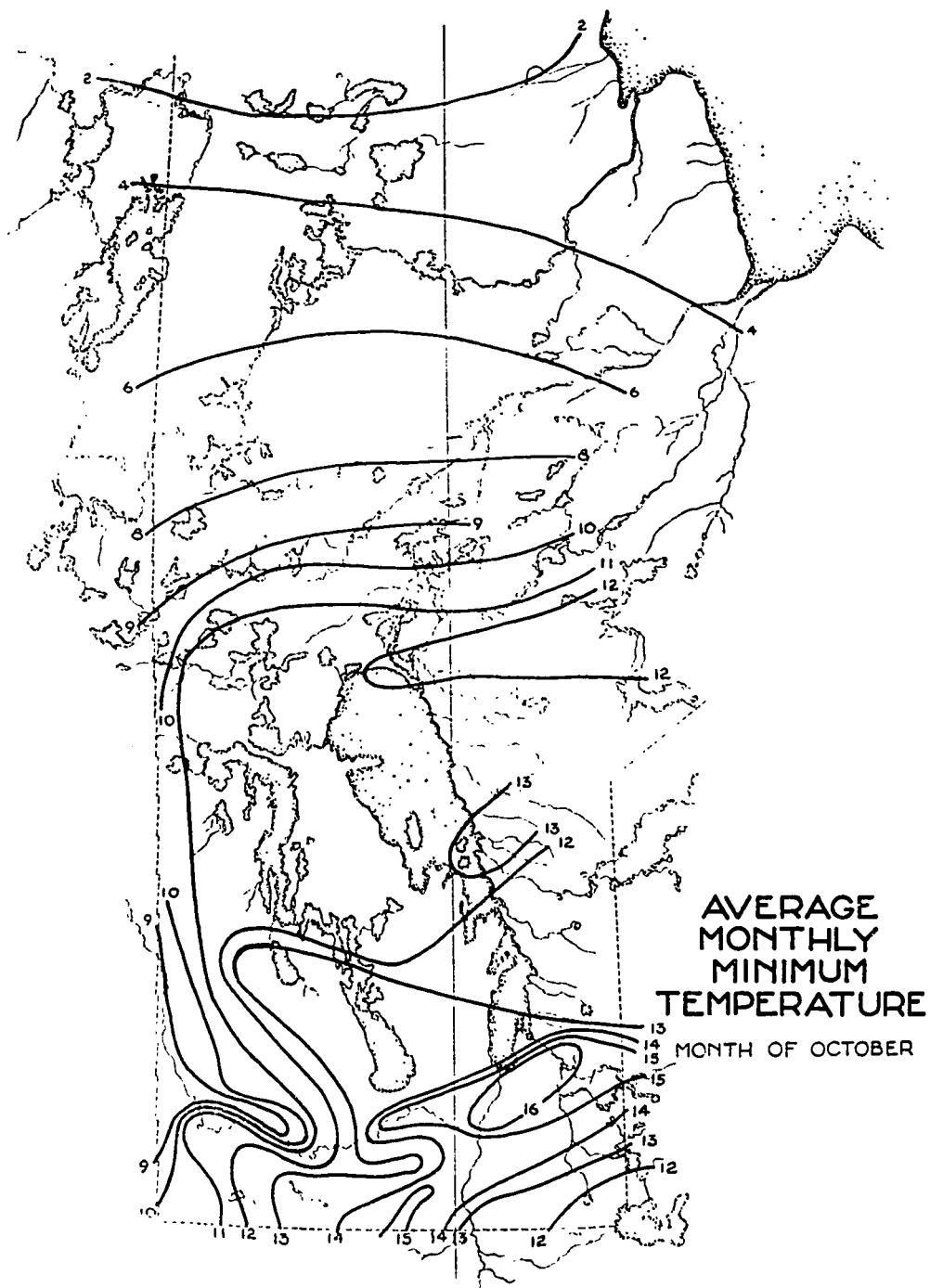
(31) In July the chance of a frosty day occurring becomes very slight, even in the far north. Along the lower Nelson river frosty days have occurred in July in nearly half the number of years of record so that one day touching at least 33F. may be expected. Over the wheat region at least one day in July is likely to have a temperature falling to about 40F. at dawn.



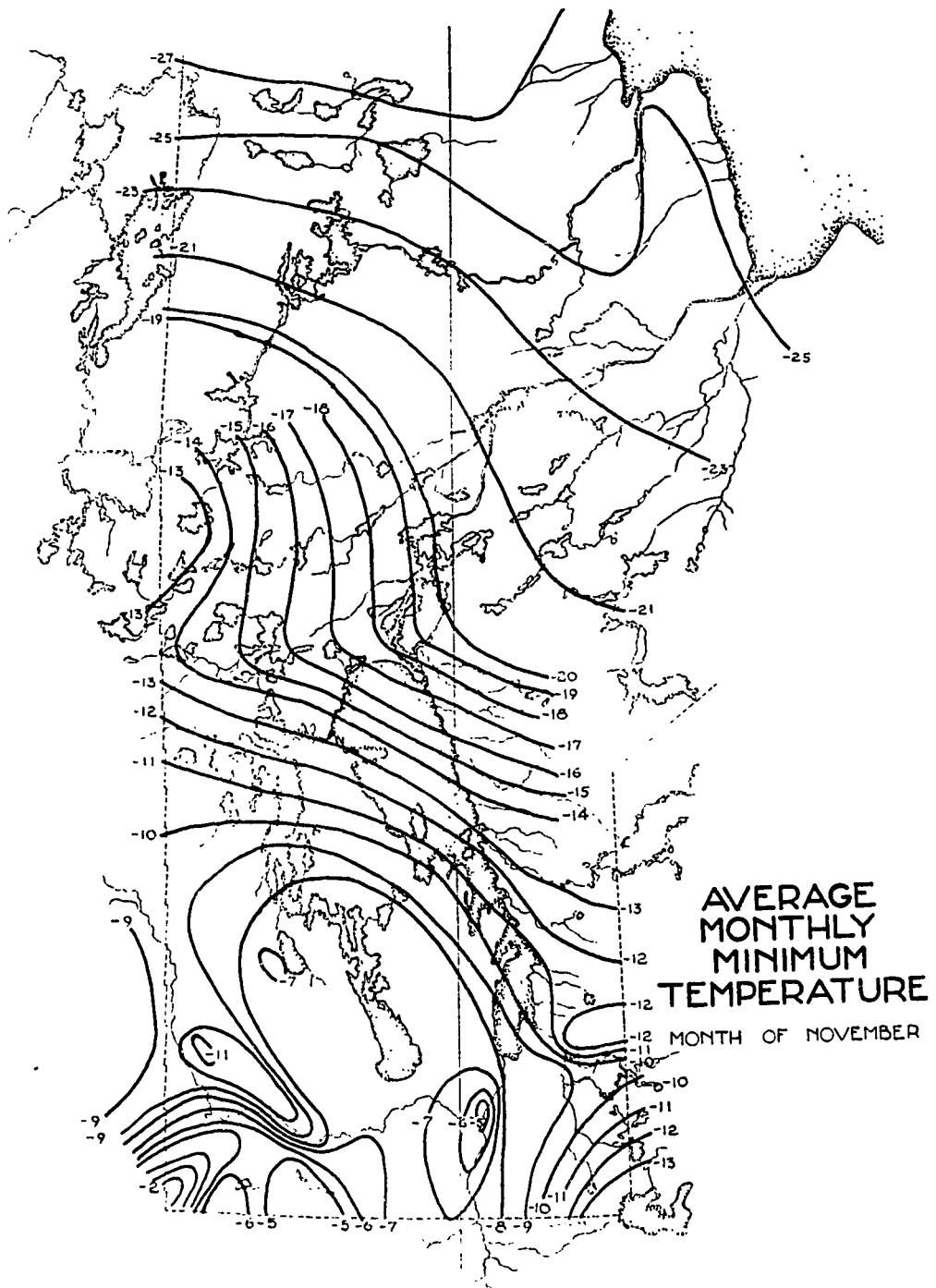
(32) In August a day with frost or near-frost is to be expected in the hilly region to the west of the Great Lakes and also in the region immediately west of the Lake of the Woods. To the north of the lakes where the data are especially scanty there is probably a region immediately west of Hudson Bay where the lowest point reached in a period of twenty years in August will be lower than 32F.



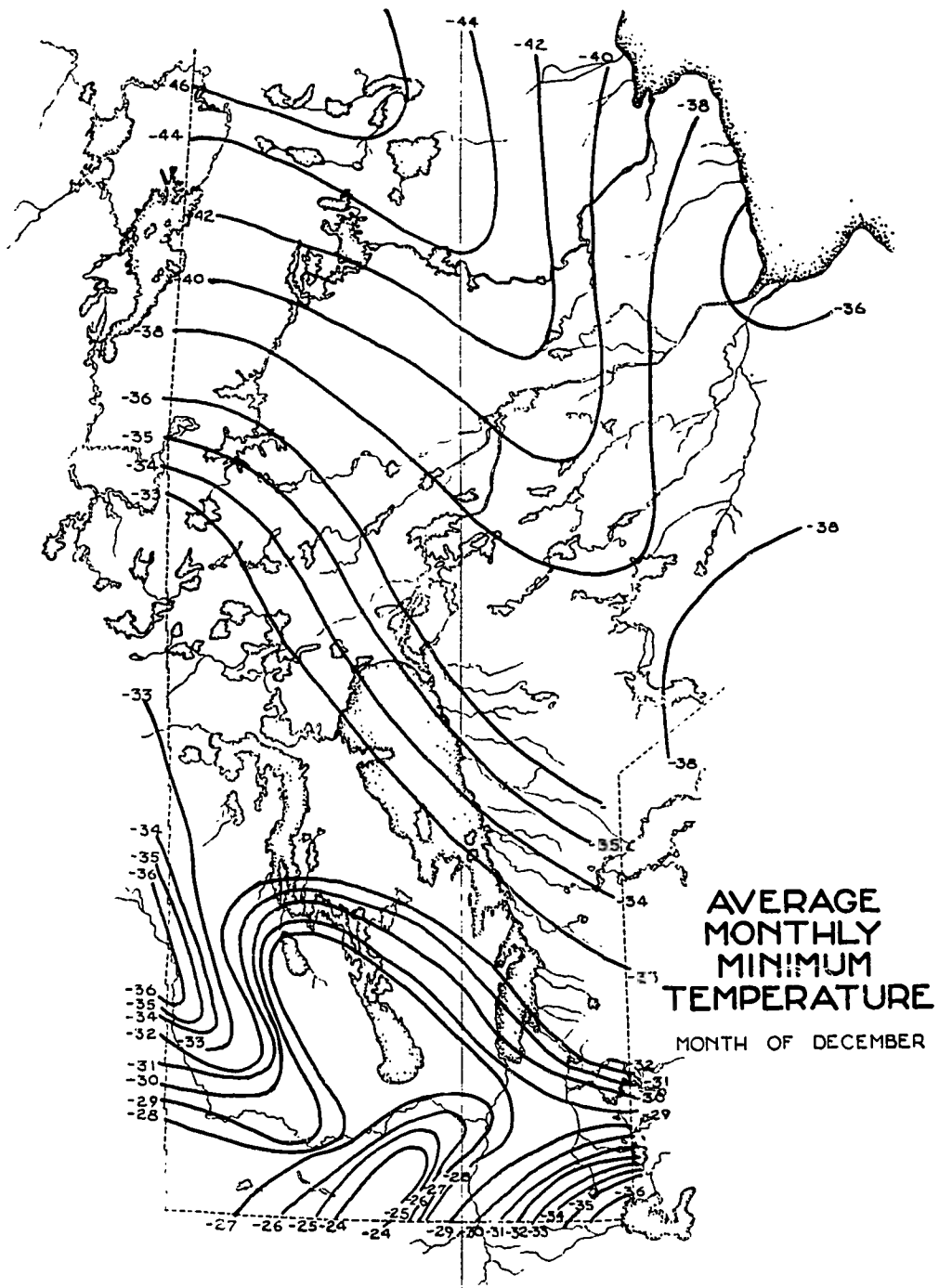
(33) In September the most energetic cold waves will likely bring five to ten degrees of frost in the south. In the far north the average is about the same. In fact, this is true of a very large area of western Canada. The average low point for September is 24F. at the bottom of Lake Athabasca; 25F. at Fort Hope on the Albany River; 24F. at Port Nelson; and 21F. at Chesterfield Inlet on the far northwest coast of Hudson Bay.



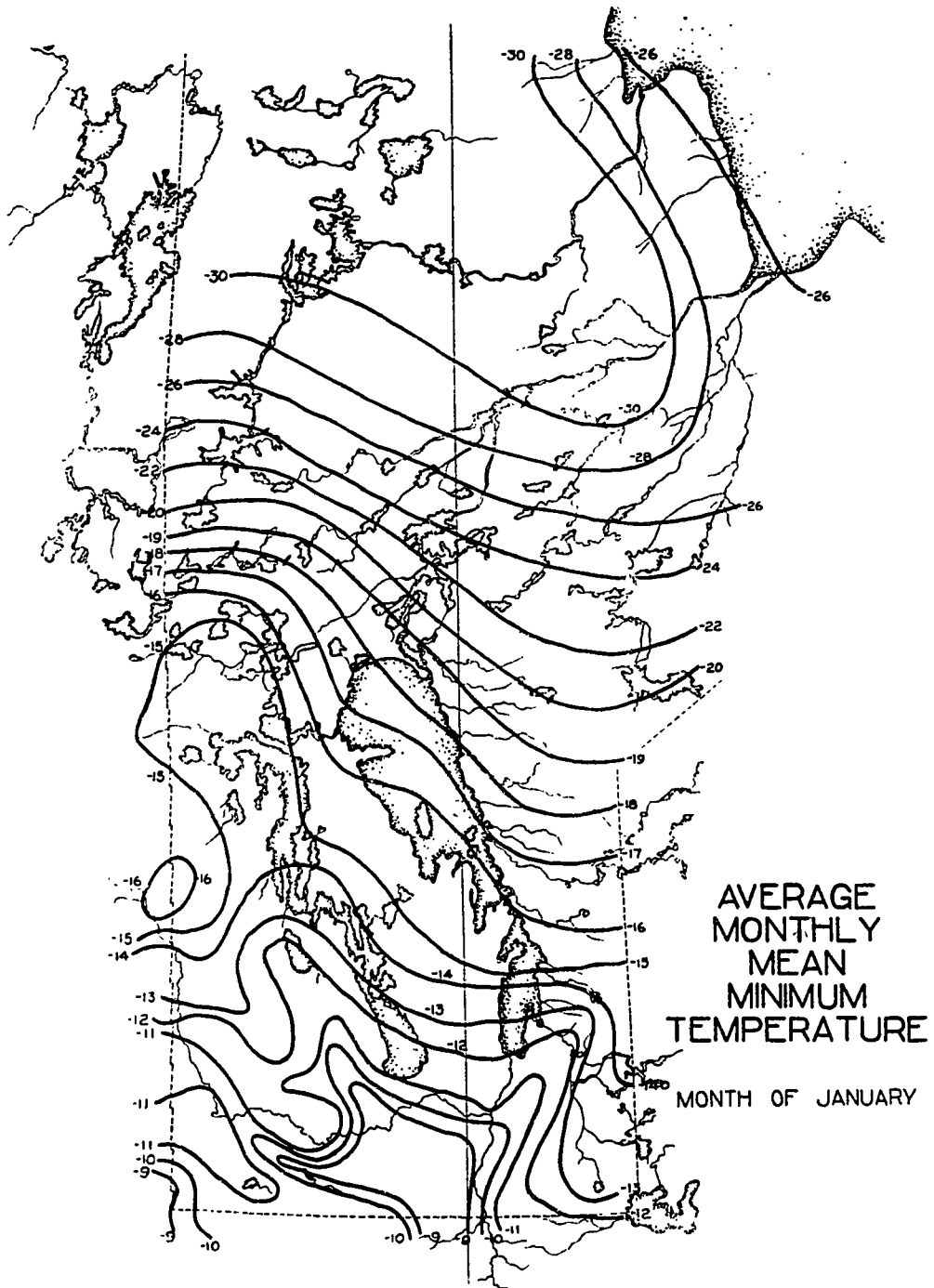
(34) In October cold waves of considerable intensity are invading the far north in an average year and a low point below zero may be reached north of the Nelson River. The average lowest to be expected north of the lakes is 2F. to 10F. above zero. Along the margin of such advancing cold waves, a low pressure wave generally forms. Clouds and precipitation and considerably less severe temperatures are then to be expected in southern Manitoba and after this disturbed period has passed the quiet air of the cold wave is usually considerably modified in temperature.



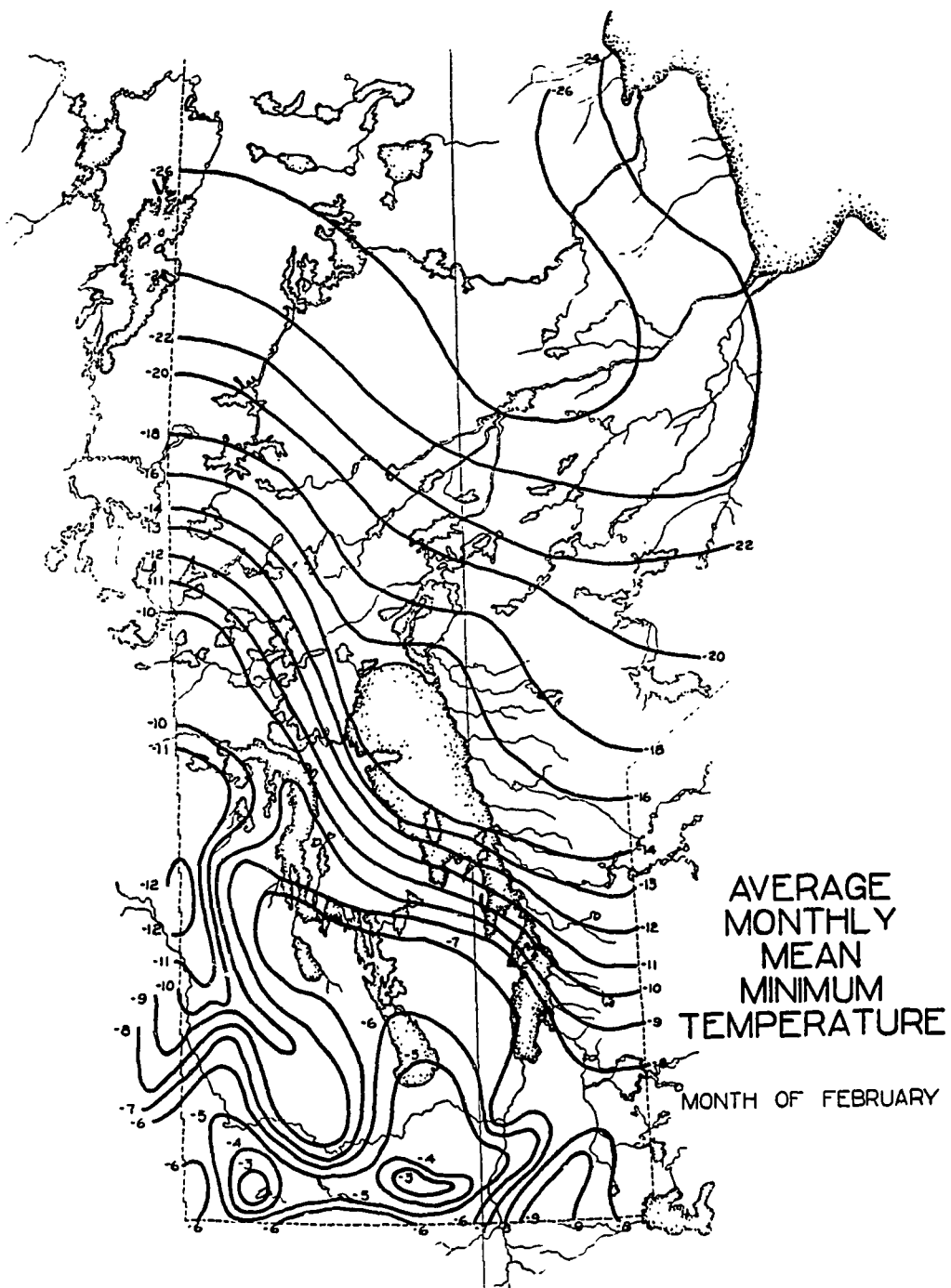
(35) In November we have much the same arrangement of isotherms of extreme cold waves as in October. The severity, however, has increased by 20F. or more. The drop in temperature across the lake region is very steep.



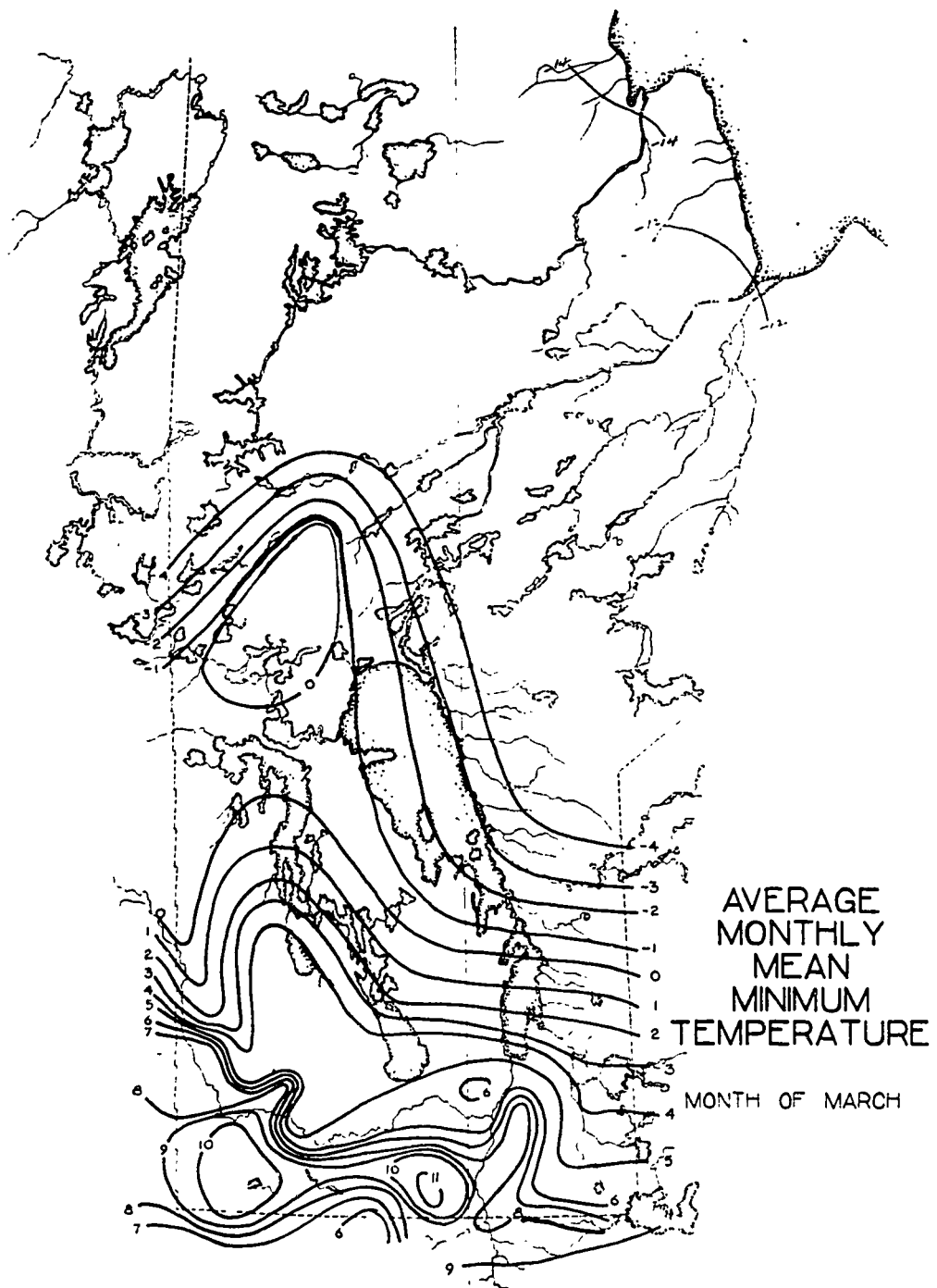
(36) In December the great cold waves often reach maximum severity. The lengthy period of darkness when outgoing radiation from the ground in the transparent air of the cold wave is not balanced by daytime insolation sometimes brings temperatures down to 40 or 45 below zero Fahrenheit north of the lakes. Such severity is scarcely ever experienced south of the lakes.



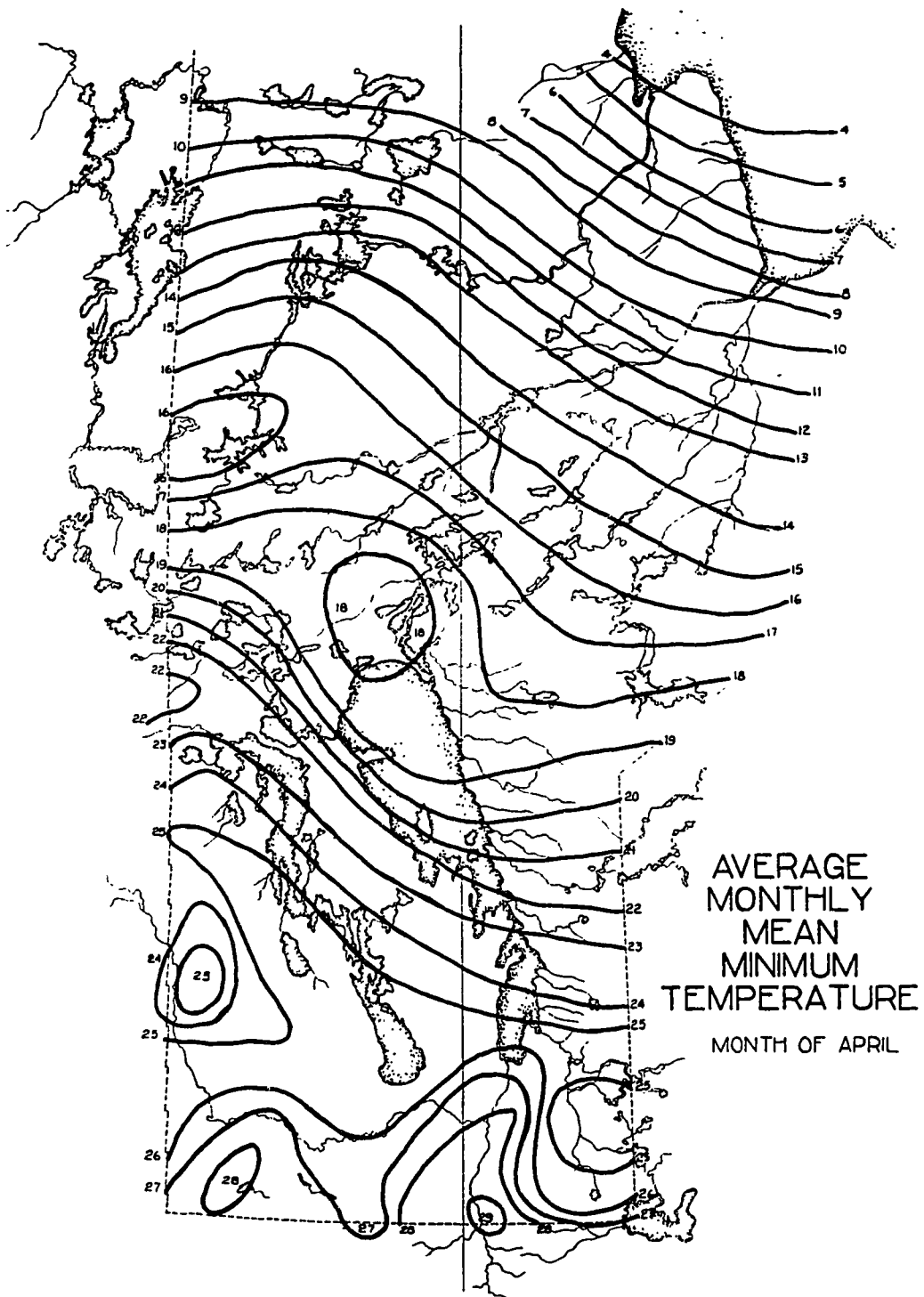
(37) The average monthly mean minimum temperature is derived from the lowest temperature of every January day during the period of observation. Since both mild and severe days have equal weight in forming the average, the resulting figure is nearly the average temperature at sunrise in January. The mildest region is the south-central portion of the province from the Souris river to the Red river. The average morning temperature there of 9 degrees below zero (Fahr.) is 20 to 25 degrees milder than that of the extreme northwestern region. The hilly region west of Lakes Manitoba and Winnipegosis has a greater effect in lowering temperature than that ordinarily caused by elevation alone.



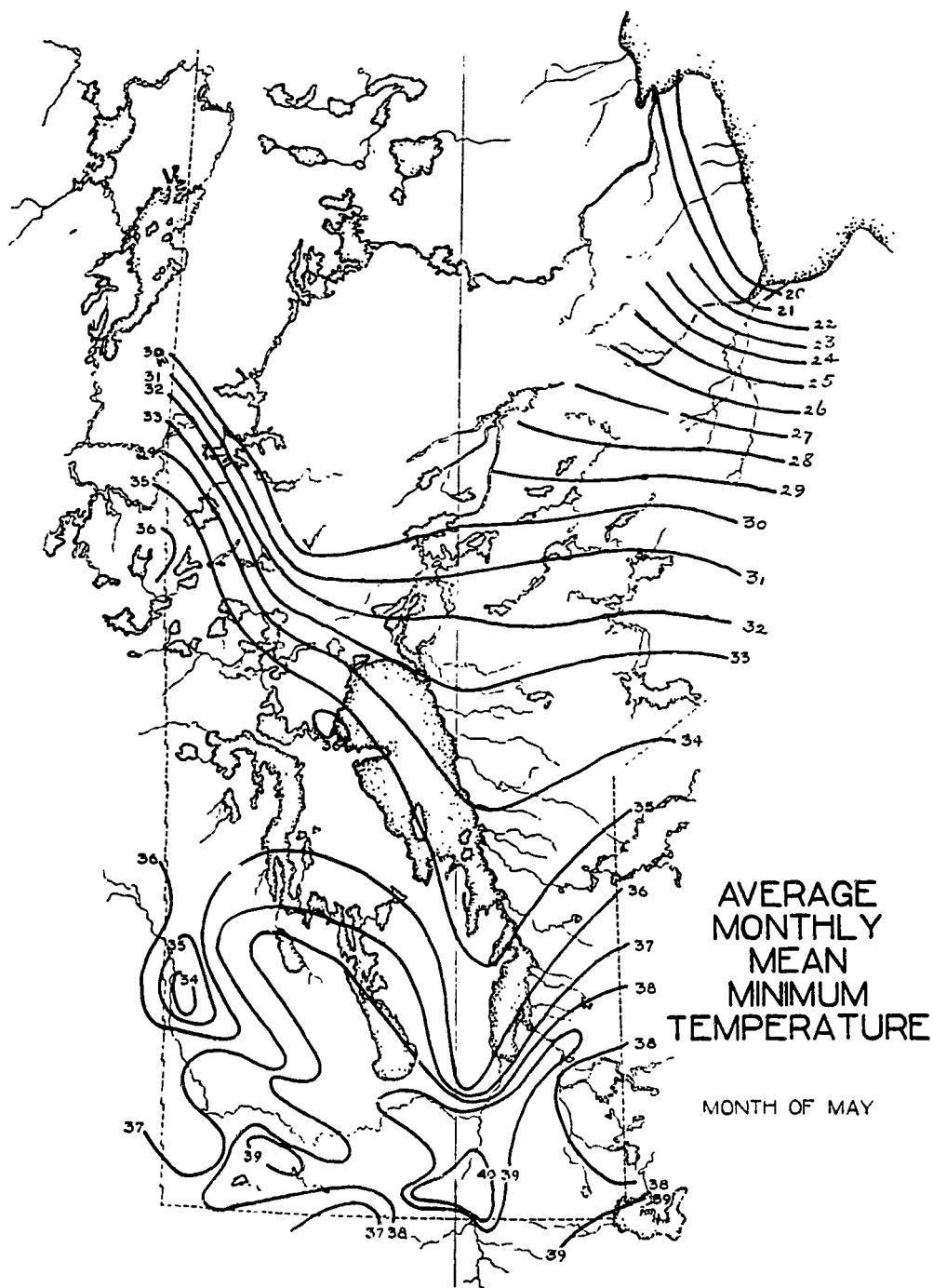
(38) There is a gain of four or five degrees in February over that of January for the coldest hour. This is probably due to the shortening of the period of unbalanced outward radiation from snowy and icy surfaces during the night.



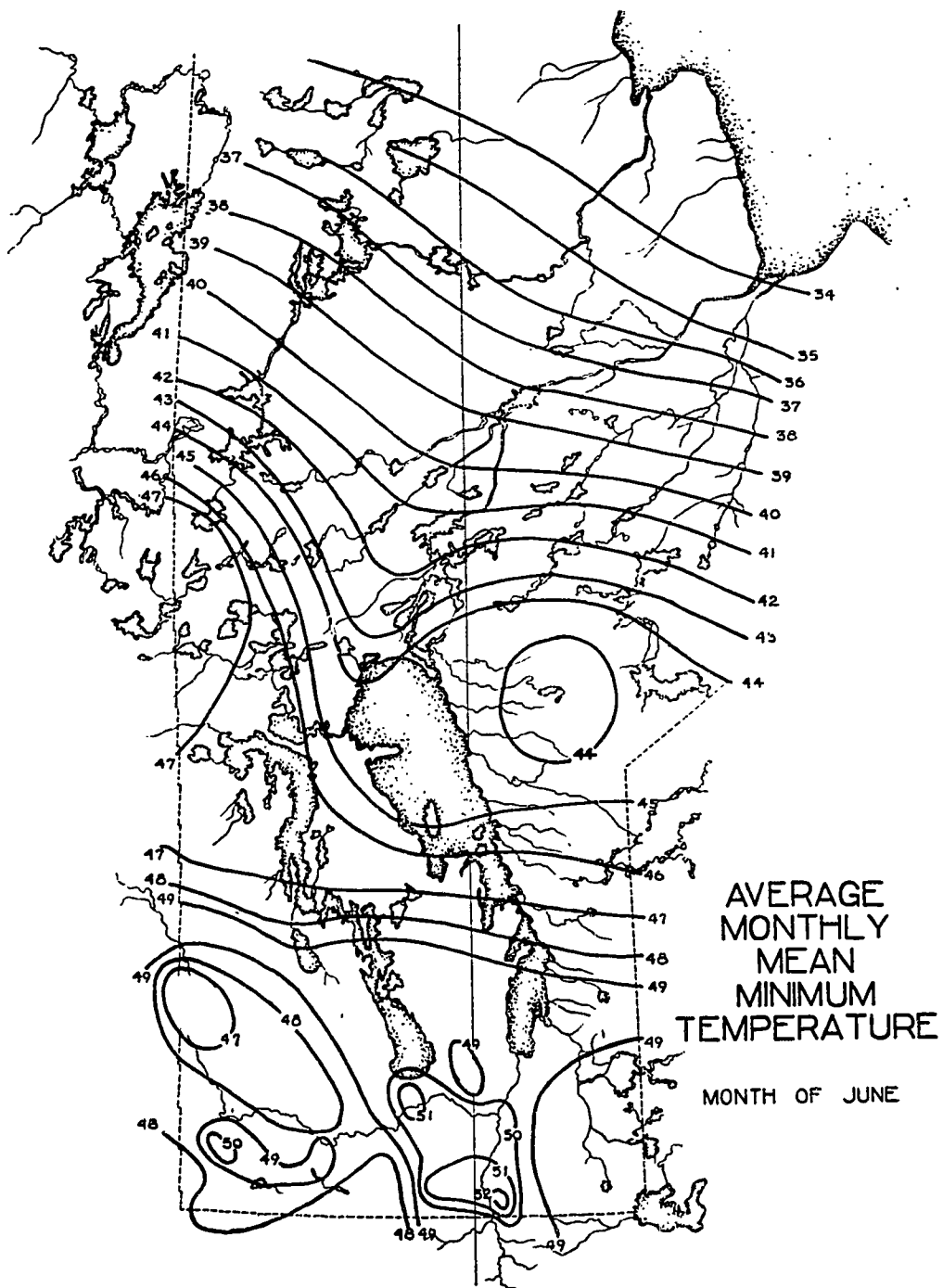
(39) The northern portion of the lake region still averages zero or lower at the coldest hour in March but the southern region averages 5 to 10 degrees above zero. The gain in thirty days has been about 15 degrees in the south and about 10 degrees in the far north. The effect of the hilly region is still quite marked.



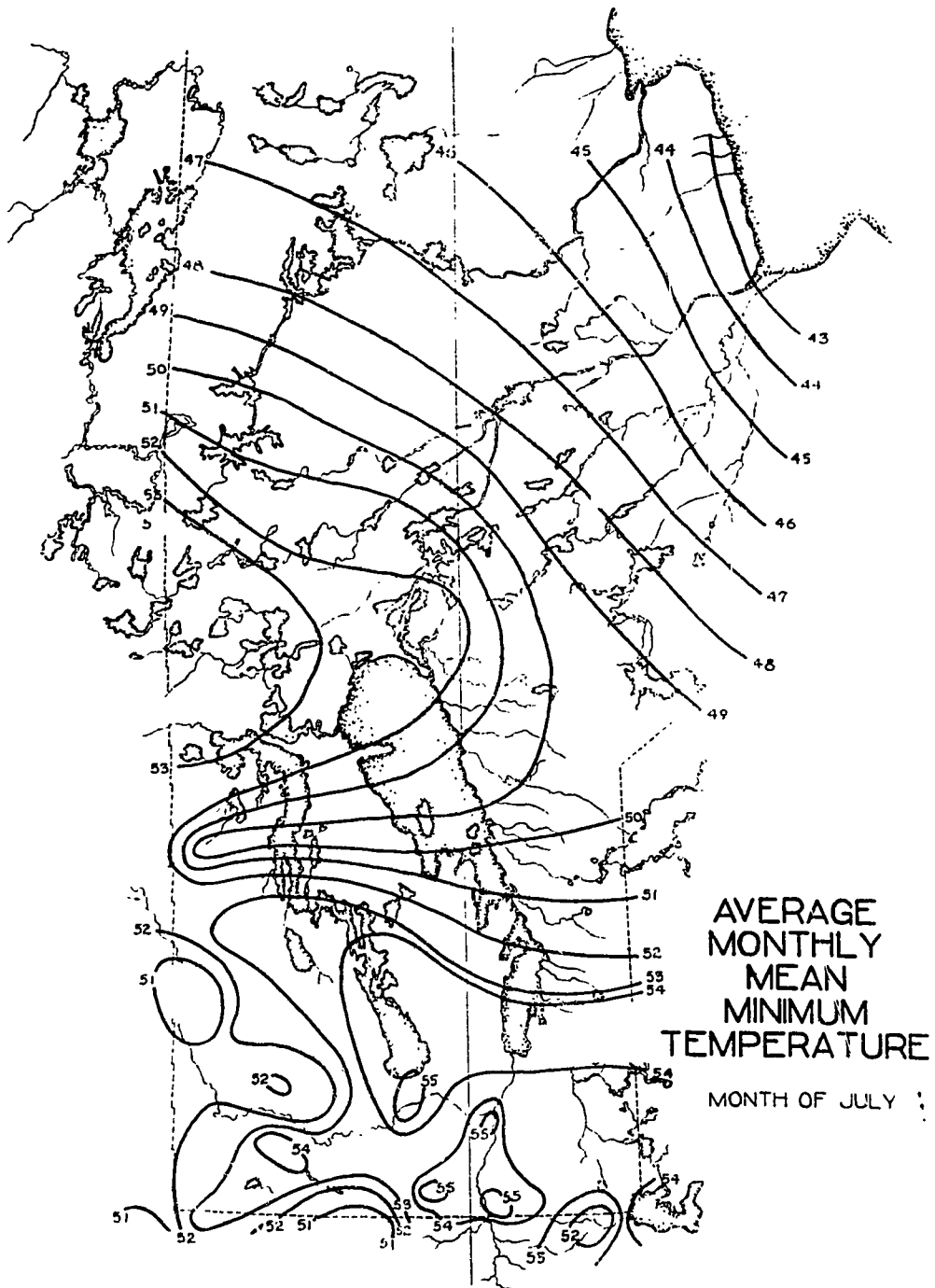
(40) The lowest temperature of the day averages above freezing after the twentieth of April in the region along and south of the Assiniboine between the Souris and Red rivers. The northern portion of the lake region of the western hills remains frosty at the end of the month. The far north remains almost wintry.



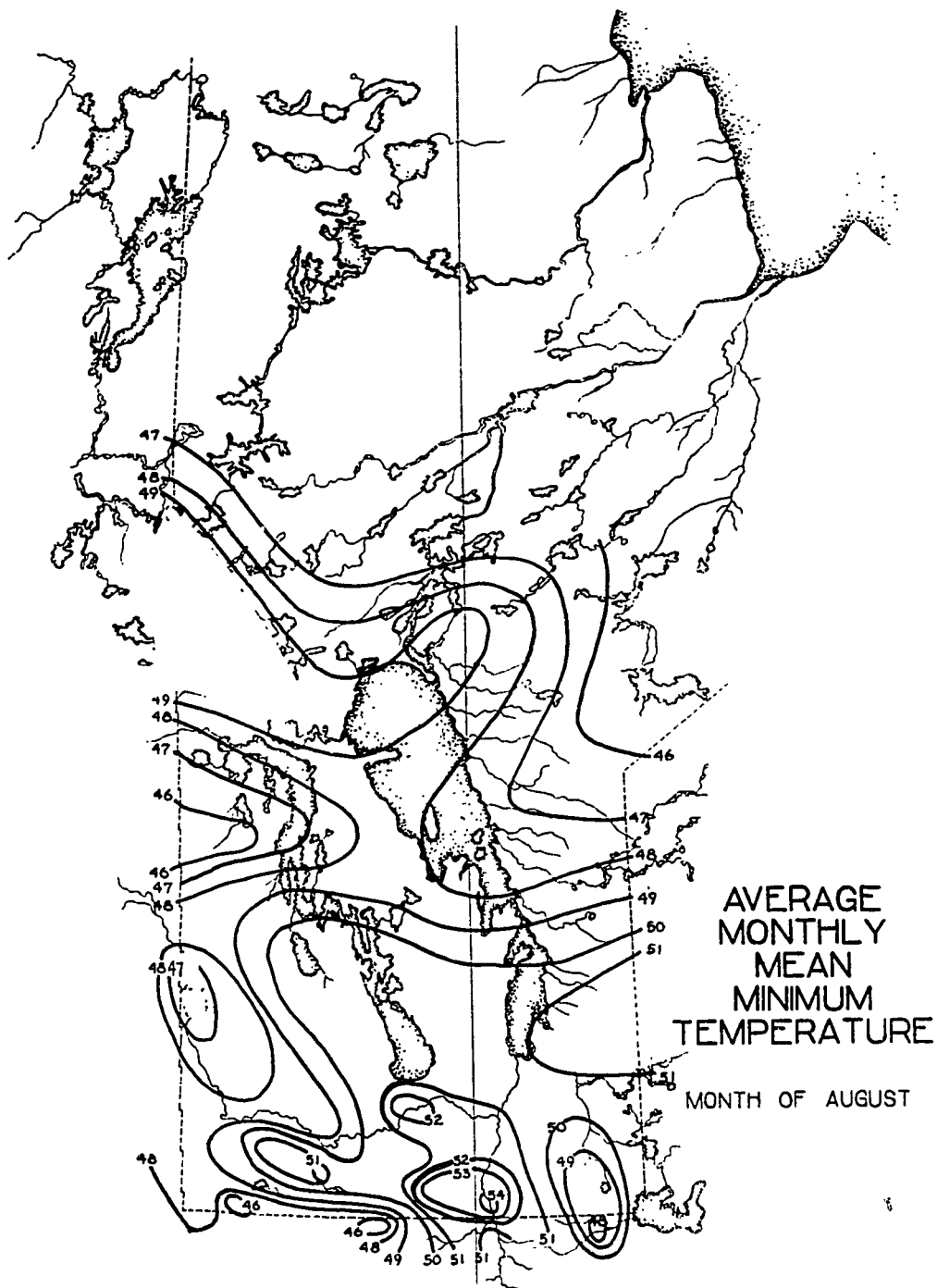
(41) Taking 43 F. as the lowest temperature for growth of grasses, we see that in no portion of the south does the temperature generally fail to fall below this point during the night. Since the average for the month may be approximately taken as the average for the 15th of the month, we see that growth at night should not be expected before the 25th in the Red River Valley.



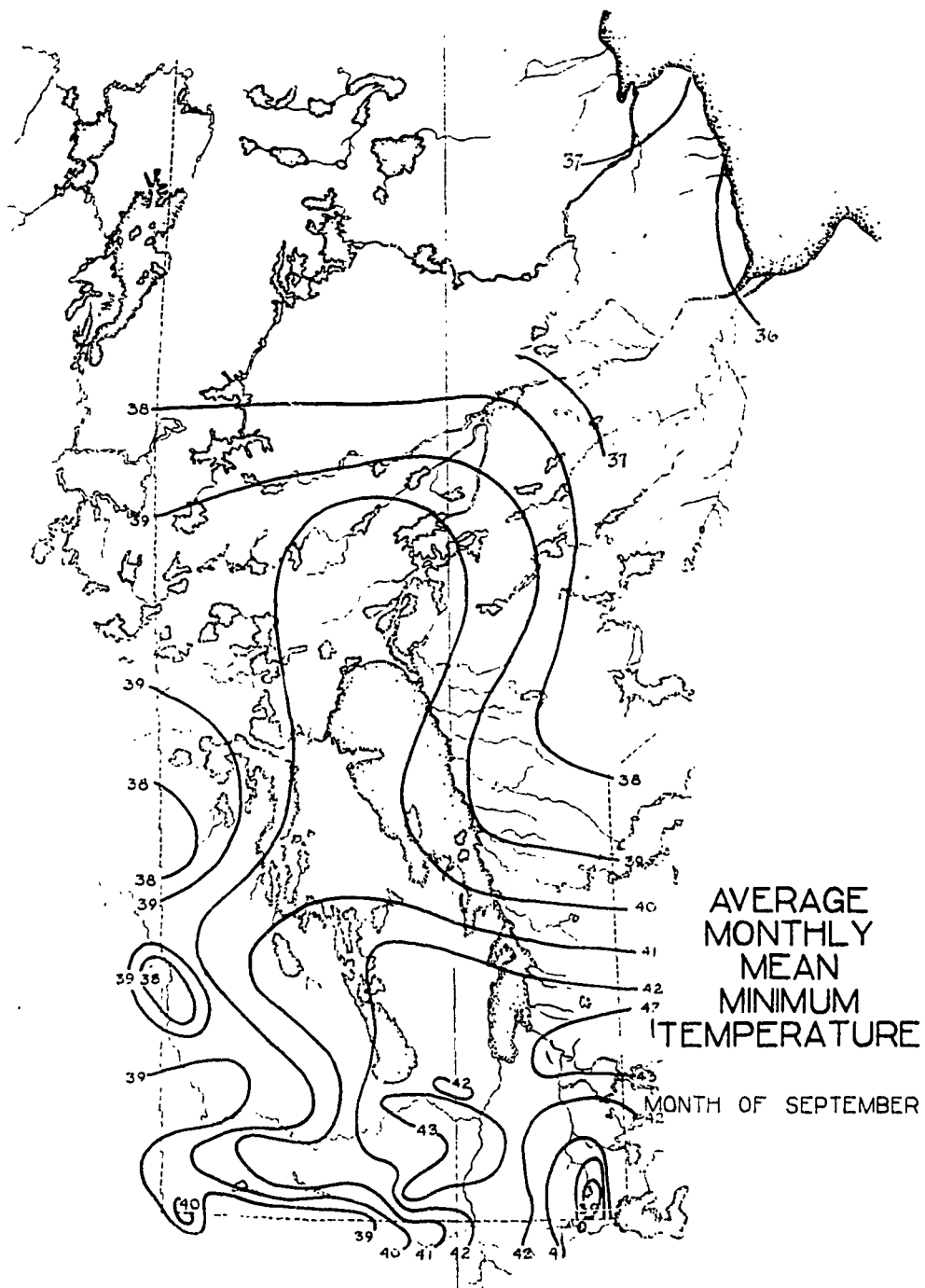
(42) In the thirty days between the 15th of May and the 14th of June, there is an average gain of about 10 degrees. Growth throughout the 24 hours should be expected after the middle of June as far north as the isotherm of 43 F.



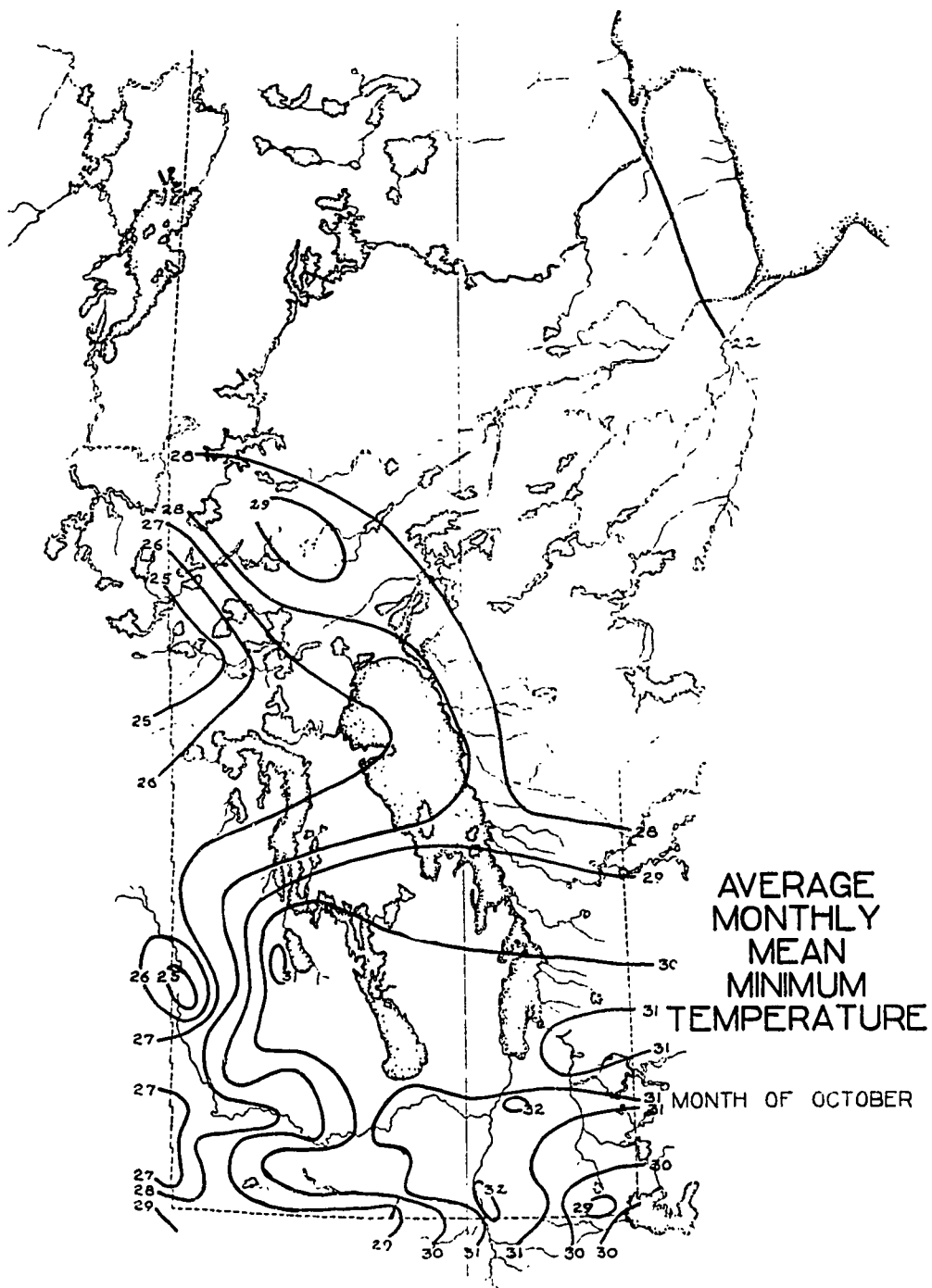
(43) This map indicates that in the whole province there is no region after the 15th of July when the temperature of the coldest hour of the day falls on the average below 43 F. The gain in thirty days has been 3 to 5 degrees in the extreme south, but 10 degrees or more in the extreme north. The isotherms still trend towards the northwest, indicating a lag in warming in the extreme northeast.



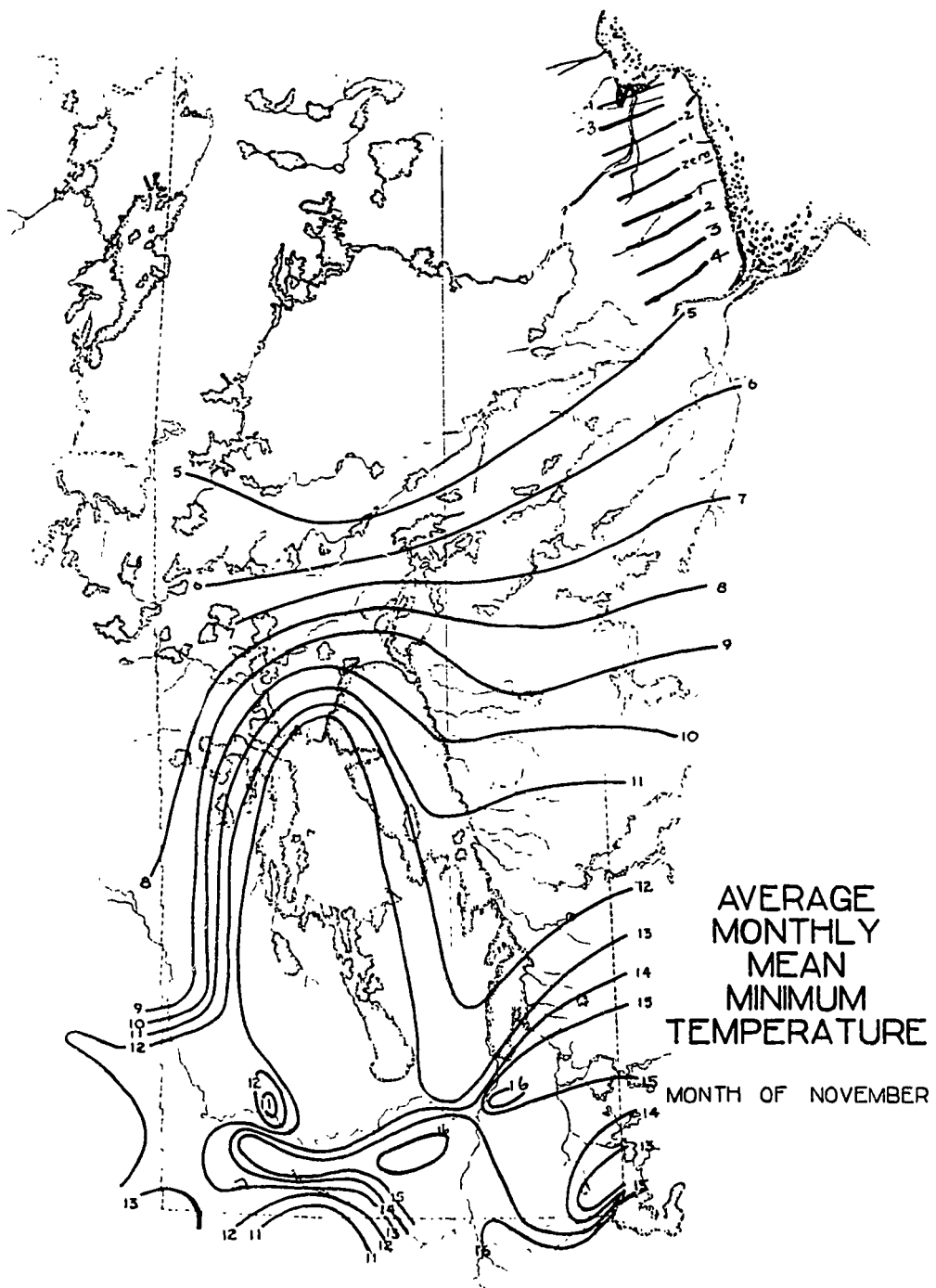
(44) There is already sign of the approaching end of summer in the western hilly region. There the morning minimum averages four or five degrees cooler than in July. In the extreme north there is little change. Port Nelson averages nearly 44 F.



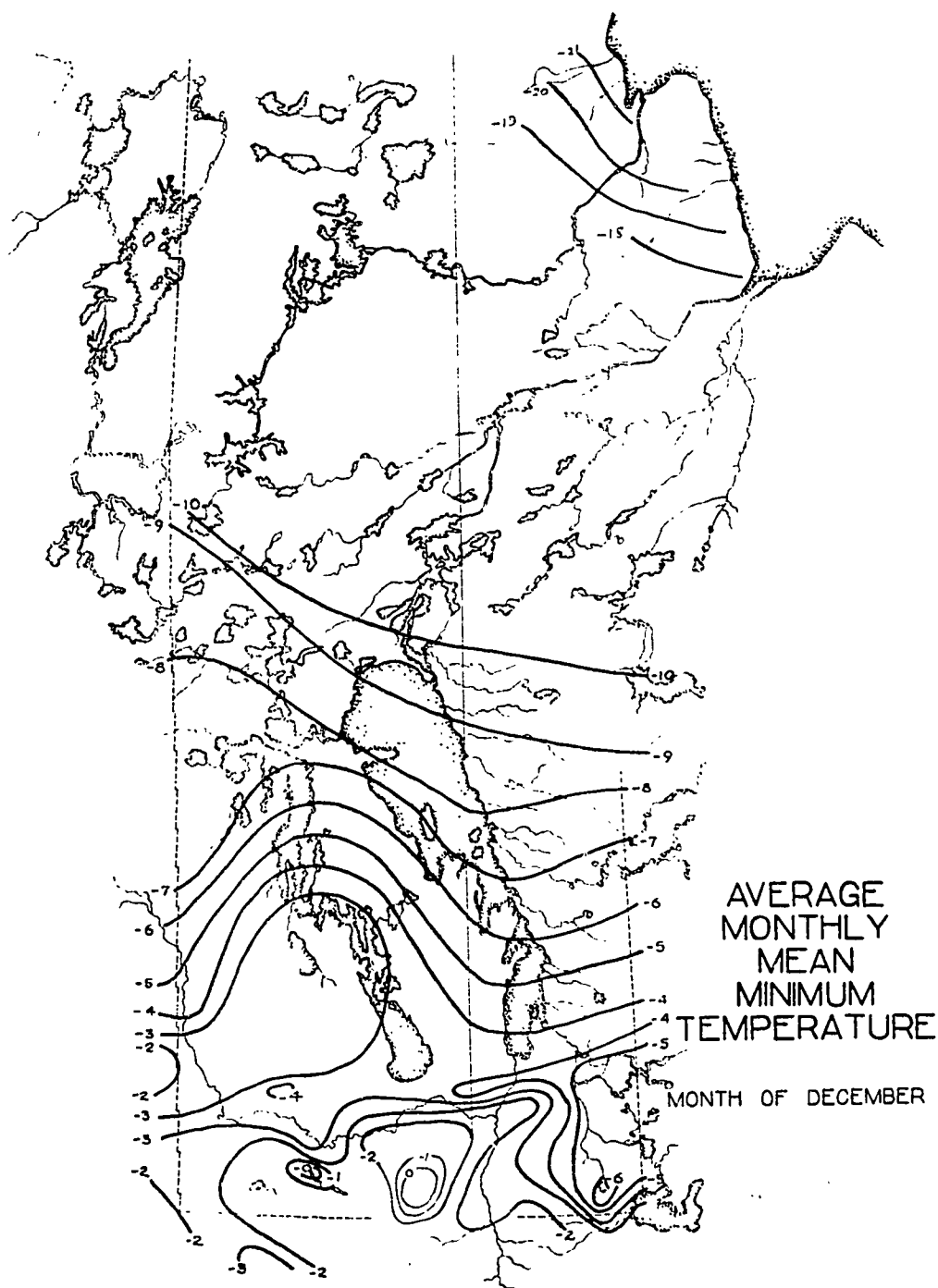
(45) In thirty days there has been a drop of about ten degrees in the central south and the extreme north. Frosty nights may be expected after the middle of the month in the hilly region and around the north end of Lake Winnipeg.



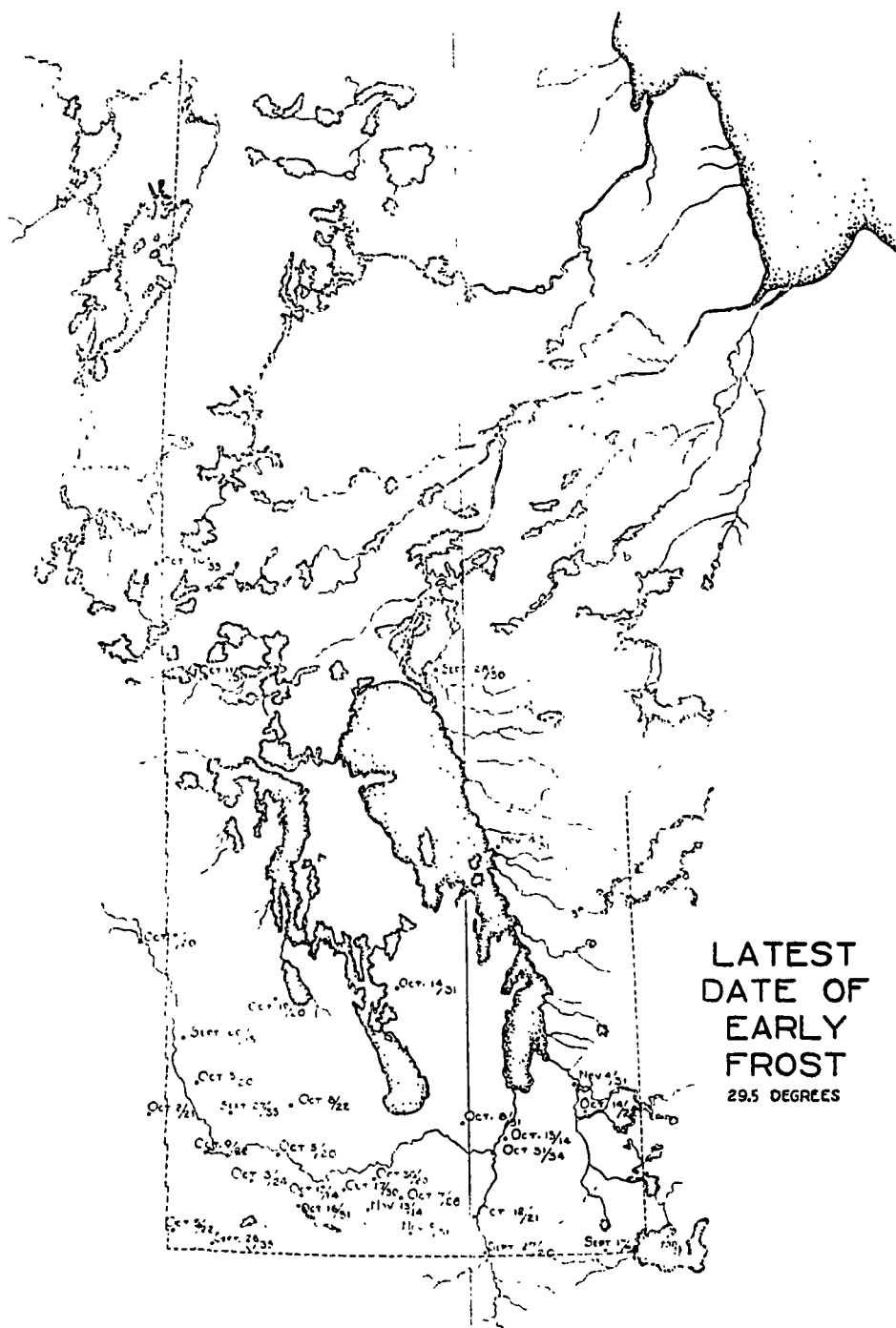
(46) Frosty nights are to be expected even in the south where the average temperature of the coldest hour is below the freezing point. The nights are wintry in the north.



(47) The slow freezing of the Great Lakes of Manitoba probably accounts for the shape of the isotherms in November.

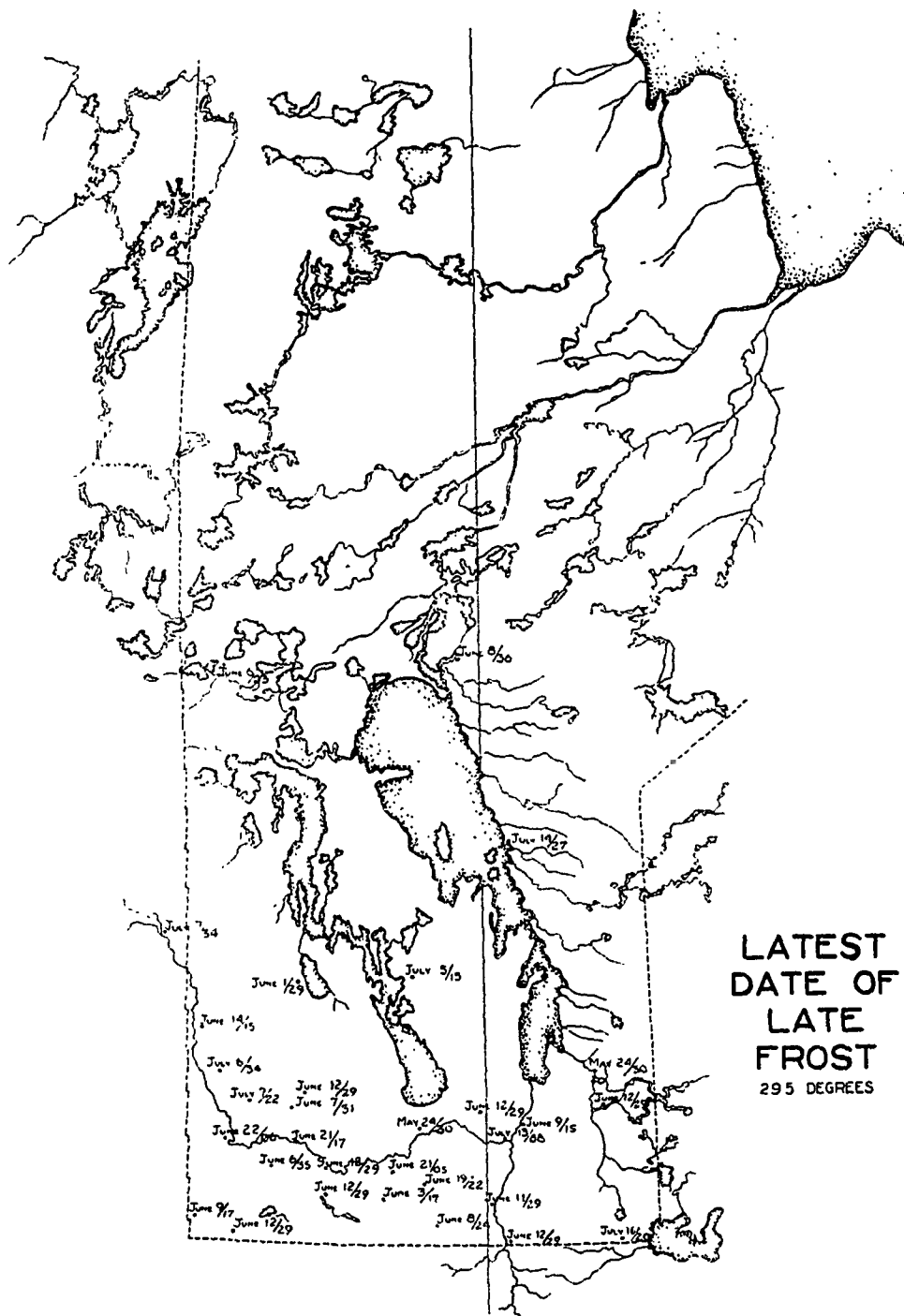


(48) The mildest region south of the Assiniboine river, averages zero or lower at the coldest hour. In the far North 15 to 20 degrees below zero may be expected at the same hour. In the central north the observations have been too few to permit the isotherms to be drawn. There is evidence that there is a region of wide extent in the northwest enclosed by an isotherm of 13 degrees below zero. Its eastern extension is not known.

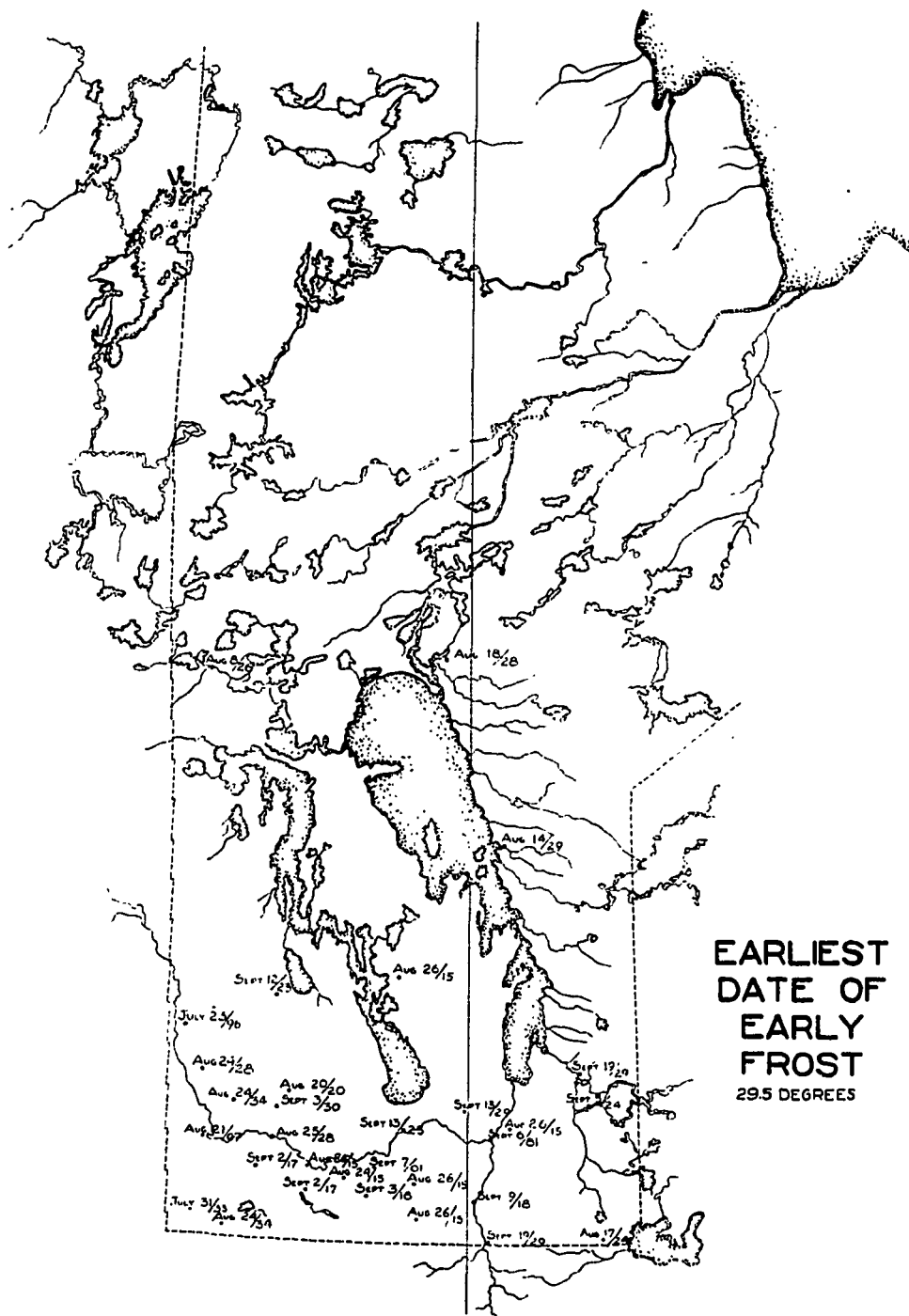


(49) Exceptionally delayed occurrence of the first heavy frost is indicated by the latest date on record. At a few points in the region between the Red and Assiniboine rivers but south of Lake Manitoba severe frost has been escaped till the end of October or even till nearly the middle of November.

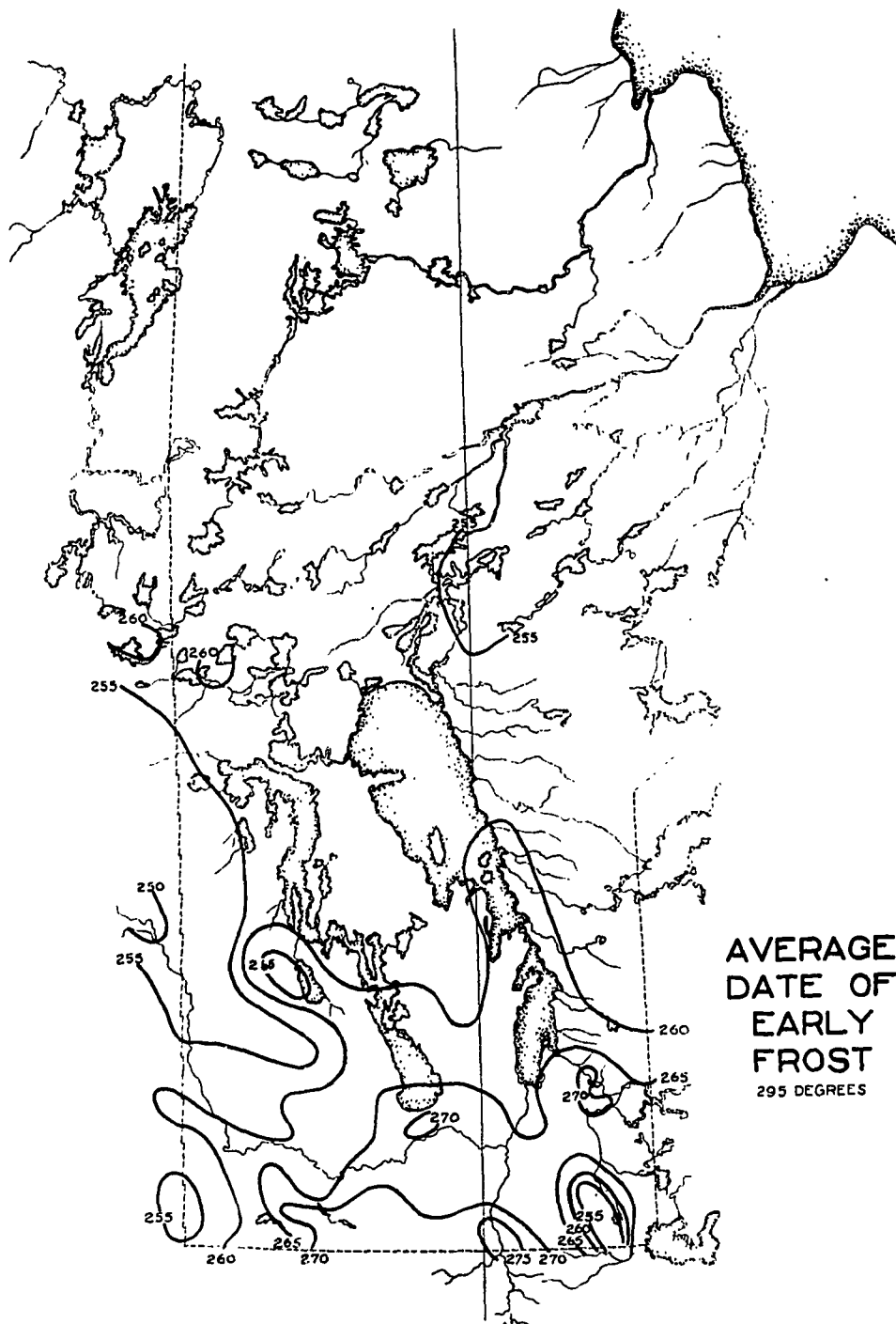
In the region of the upper Assiniboine and in the extreme southeast the end of September or the first week of October is the limit of delay for hard frost.



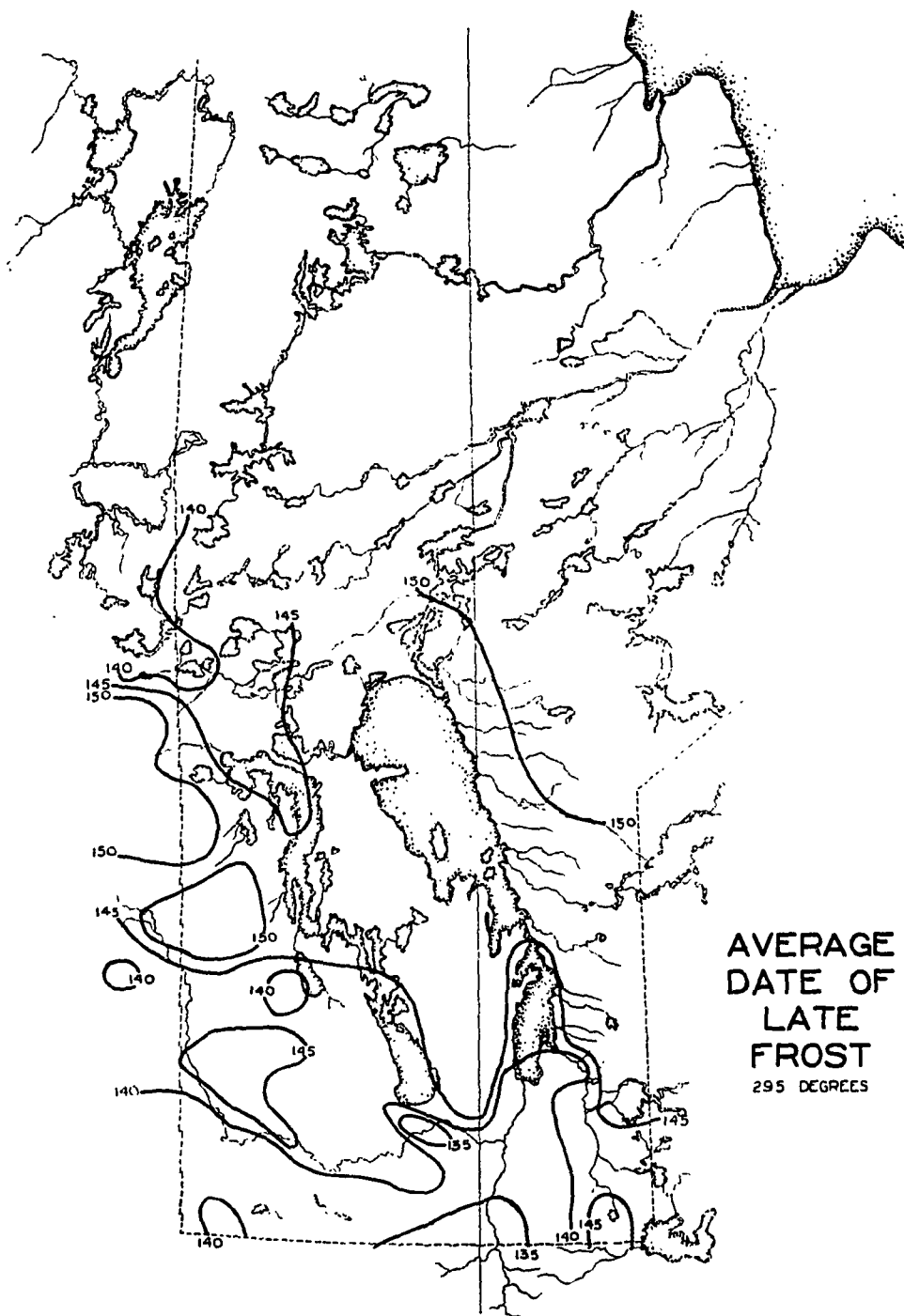
(51) In some exceptional years a heavy frost occurs after summer is well under way. It has occurred as late as the second week of June in the central south and in July in the interlake region. Fortunately, these delayed severe frosts are rather patchy in their incidence and do not appear to cover a very wide region every year.



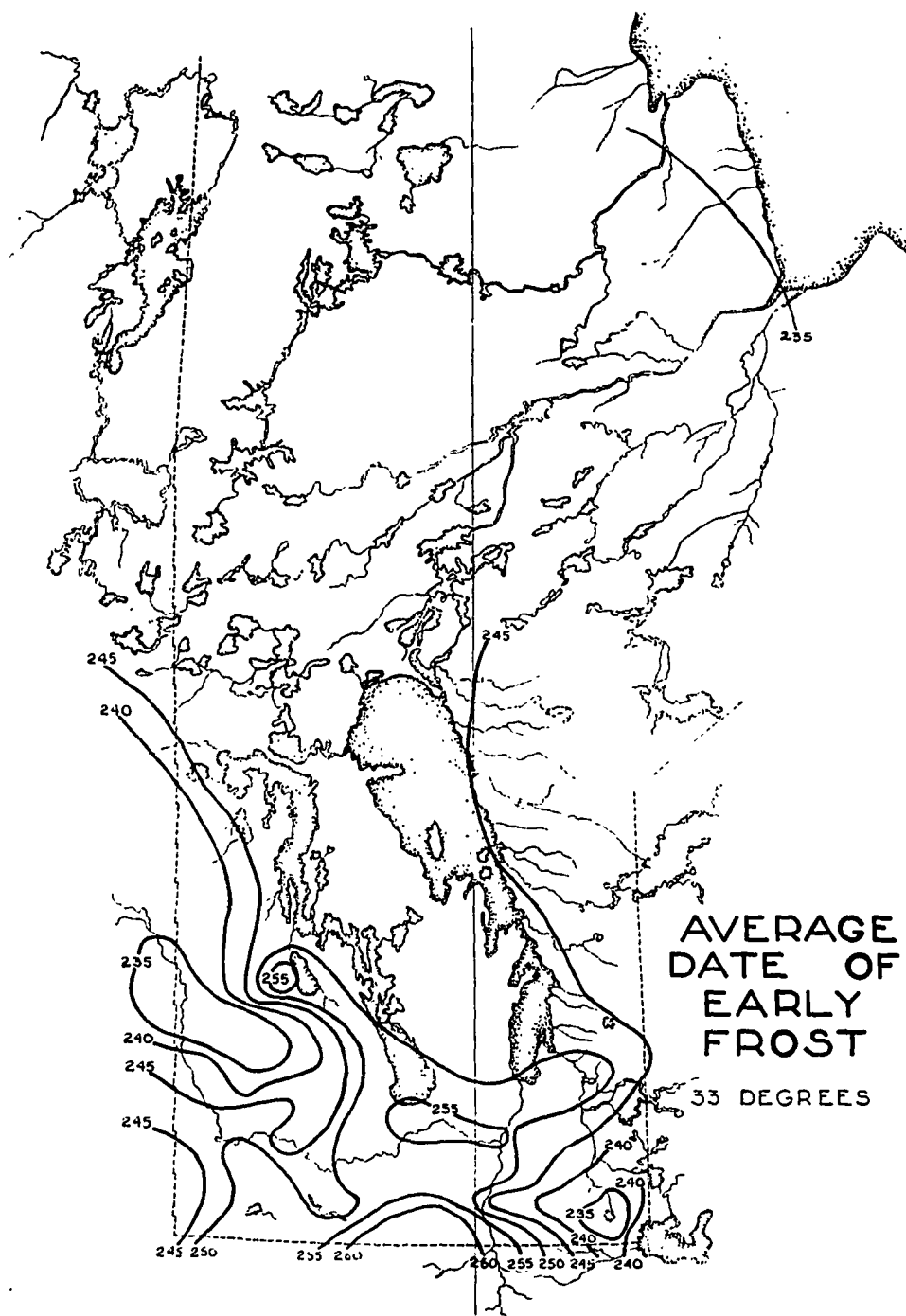
(52) The first heavy frost of the autumn has in some years occurred in August as early as the 25th in the southern districts. It has appeared even in July at a few points in the western hilly region.



(53) The average date of the first heavy frost of the autumn falls in the last week of September south of the lakes, except east of the Red river and the western portion of the Souris river district. In these districts it falls in the second week. In the interlake region the average date is in the third week.



(54) The average date of the last heavy frost of spring is about the 15th to the 20th of May in the region between the Souris and Red rivers. Between the Assiniboine and Lake Manitoba as well as east of the Red river, the date is about the 20th to the 25th. West of Lake Winnipegosis heavy frost occurs on the average as late as the first of June. The dates in this hilly region are, of course, for cultivated bottom lands.



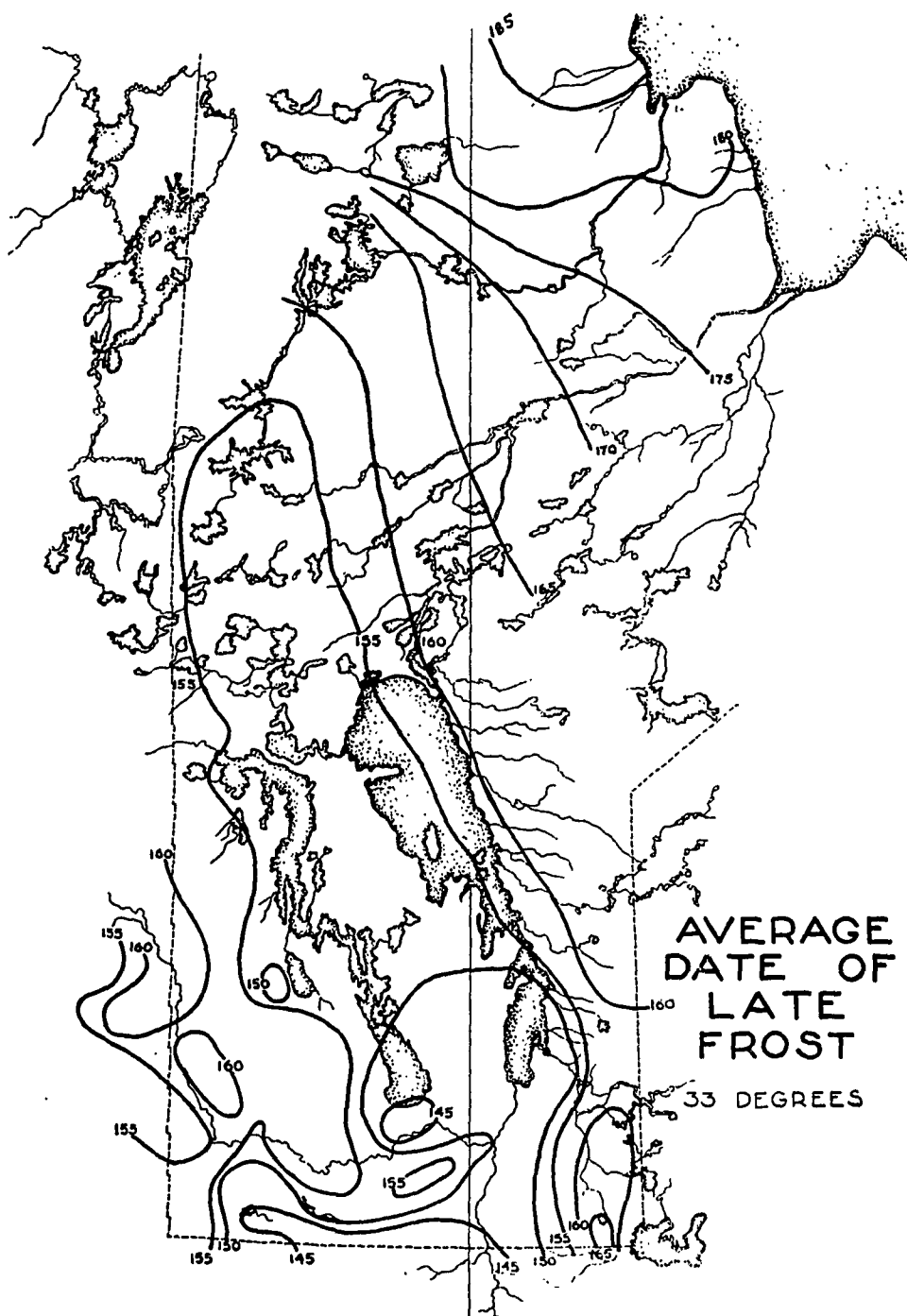
(55) A light frost often, or generally, accompanies a reading of 33F. in the thermometer shelter. This shelter is about four feet above the ground while the air in contact with the ground on a calm night is often somewhat colder. The first frost of autumn is not uniformly, or even generally, so light as this. In many years the first frosty night may go considerably below the freezing-point. The average date of all earliest occurrences in each year of a minimum temperature below 33.5F. has been determined and plotted on this map.

(The date is given as the day of the year, not as the day of the month. The 255th year-day is the 12th of September; the 260th year-day is the 17th of September; the 235th is the 23rd of August.)

These early frosts occur very erratically, but on still, clear nights when outgoing radiation is very high, bottom lands may fill with chilled air draining very slowly from adjacent highlands and reach frost while the highlands escape freezing. A light wind is generally accompanied by enough mixing to prevent stratification of air. On clear but windy autumn nights the danger of local frosts is accordingly less than on calm, clear nights.

The region immediately west of the Lake of the Woods and the hilly region along the Saskatchewan boundary may experience these local frosts during the last two weeks of August. The same is true of Nelson and Churchill.

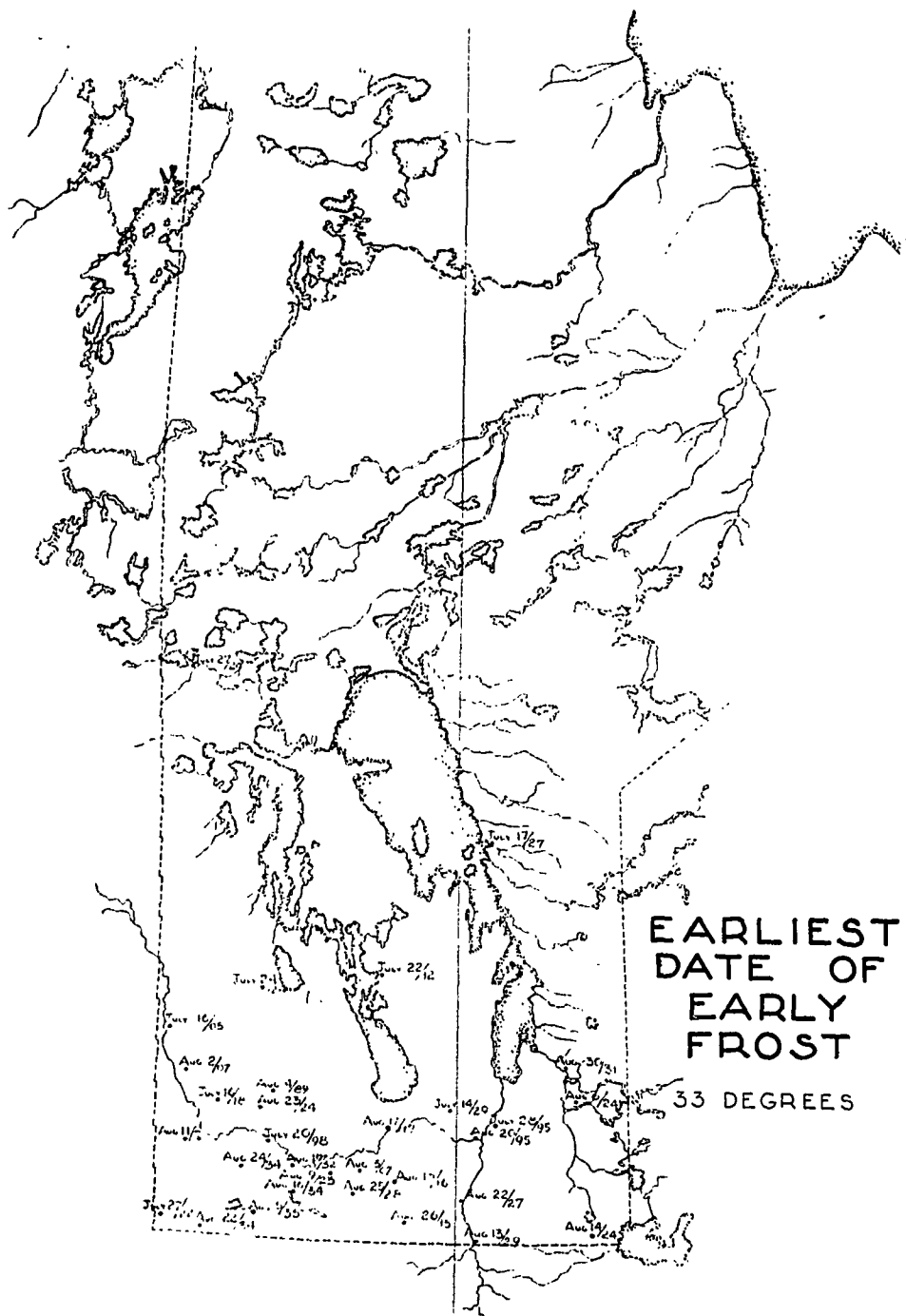
In the central south these first frosts, on the average, come during the first two weeks of September. In the region north of the Great Lakes of Manitoba observations have been too few to show more than the fact that light frosts may occur early in August or be delayed till the middle of September. Probably the fifteenth of August will be found to be near the average date in the northern areas.



(56) The last date in spring when light frosts may be expected is determined from the average date of the occurrence of a minimum temperature lower than 33.5 F. in a thermometer screen which is four feet above the ground.

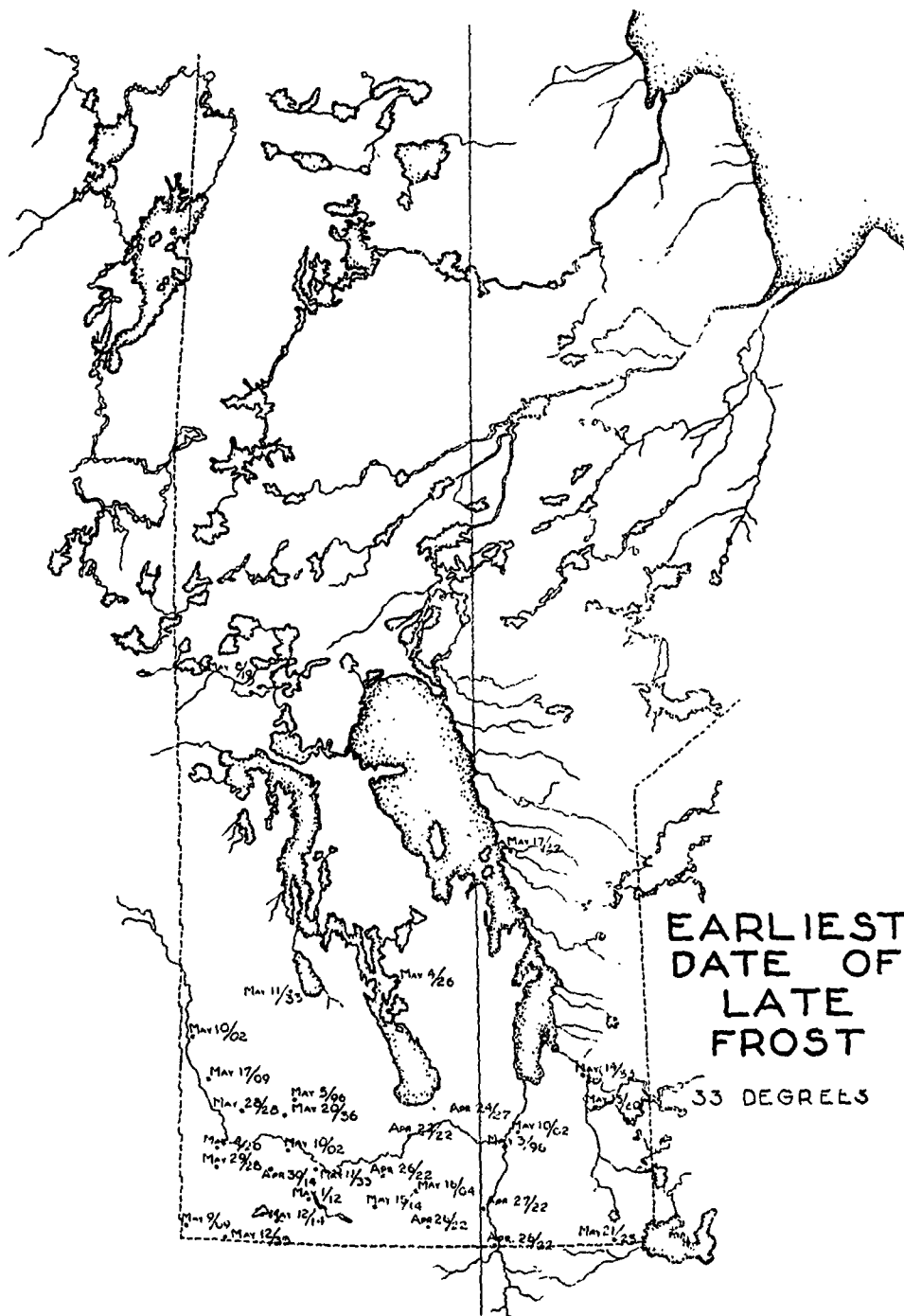
The average date is the 160th day of the year or the 9th of June in the hilly region along the Saskatchewan border and in the region immediately west of the Lake of the Woods. In the central south just north of the International Boundary these local frosts are usually over by the 145th year-day or the 25th of May.

In the far north we find the date averaging 176 at Nelson (25th of June) and 184 (3rd of July) at Churchill.



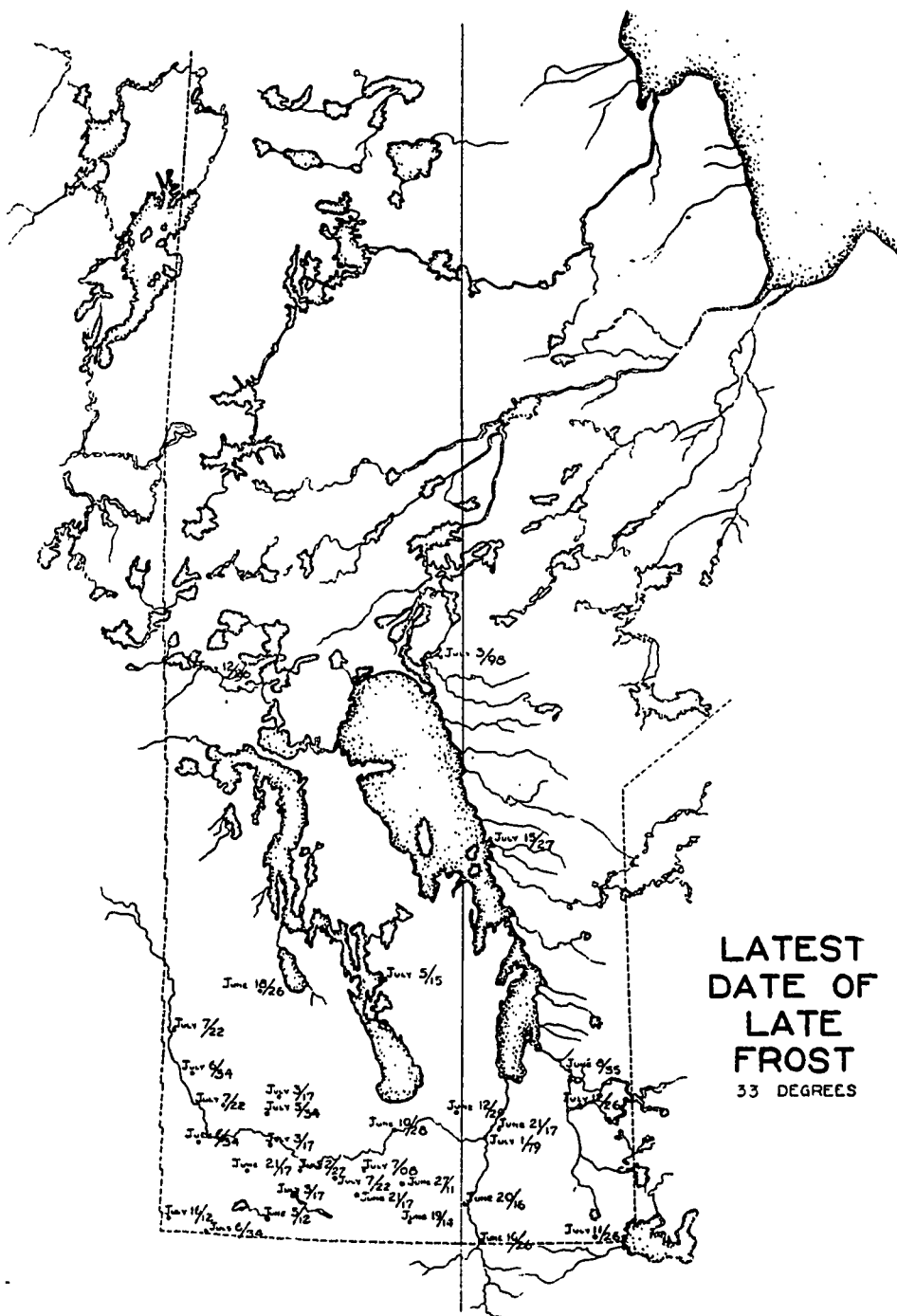
(57) The earliest date in the autumn when a light frost has been recorded has been indicated on this map for southern stations of fairly long record. In a region where light local frosts may occur at any time in summer, some convention to distinguish the last frost of spring from the first frost of autumn was necessary. The 15th of July seemed to be a suitable date for midseason so frosts occurring on and after this date are regarded as early frosts. At one point on this map a frost occurred on the 14th of July and this has been taken as an early frost.

Farther north light or sharp frosts may occur in any week of June, July, or August, although apparently August is more frost-free than any other month.

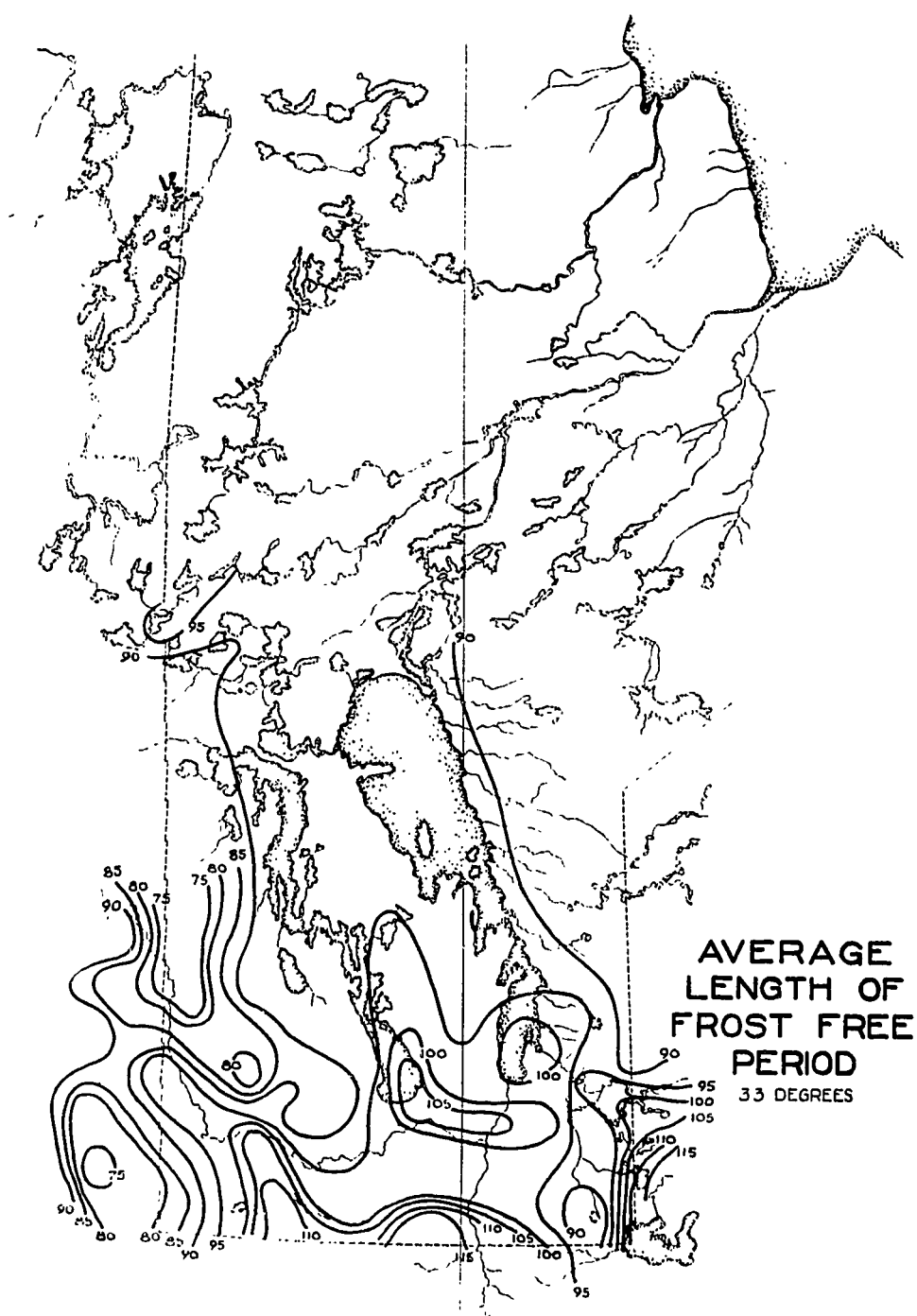


(59) In some years spring has been remarkably free from light frosts. The earliest date when light frosts ceased to occur has been plotted on this map. Since 1901 there have been years when no frost occurred after the last week of April along the lower portion of the Assiniboine river and along the Red river. As far north as the interlake region there have been years with last frost coming quite early in May.

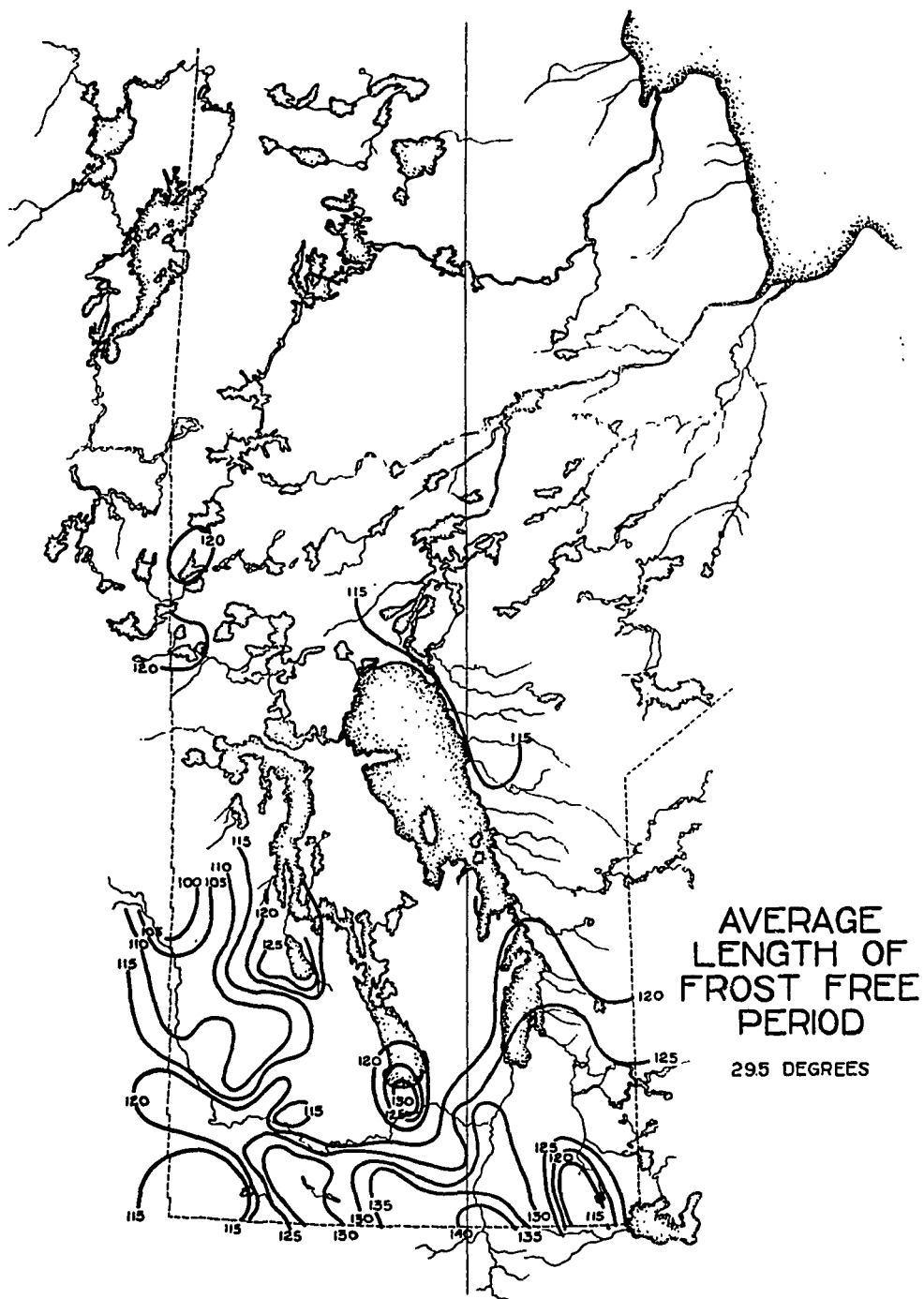
In the far northern territory the 15th of June appears to be the earliest date on record, except the 4th of June, 1878, at York Factory at the mouth of the Nelson river.



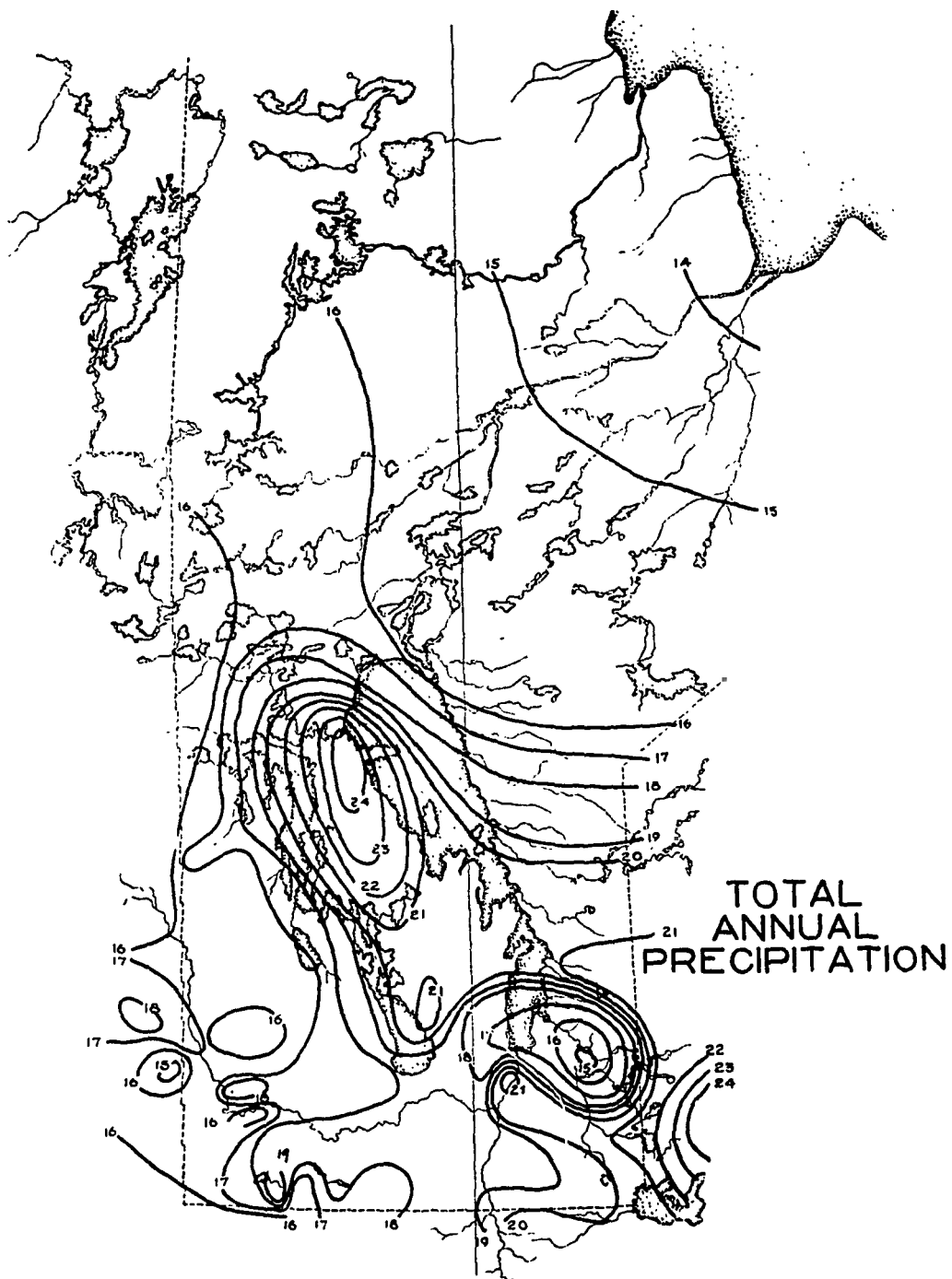
(60) The latest date on record of occurrence of freezing temperature at the ground depends somewhat on the length of record at each station but it is fairly evident that stations close to the banks of rivers or shores of lakes may escape an extremely late light frost. The first week in July in the extreme southwest and the second week in July in the extreme southeast have brought frost. The region between the Red and Assiniboine rivers but south of Lake Manitoba appears to have had no frost after the third or fourth week of June.



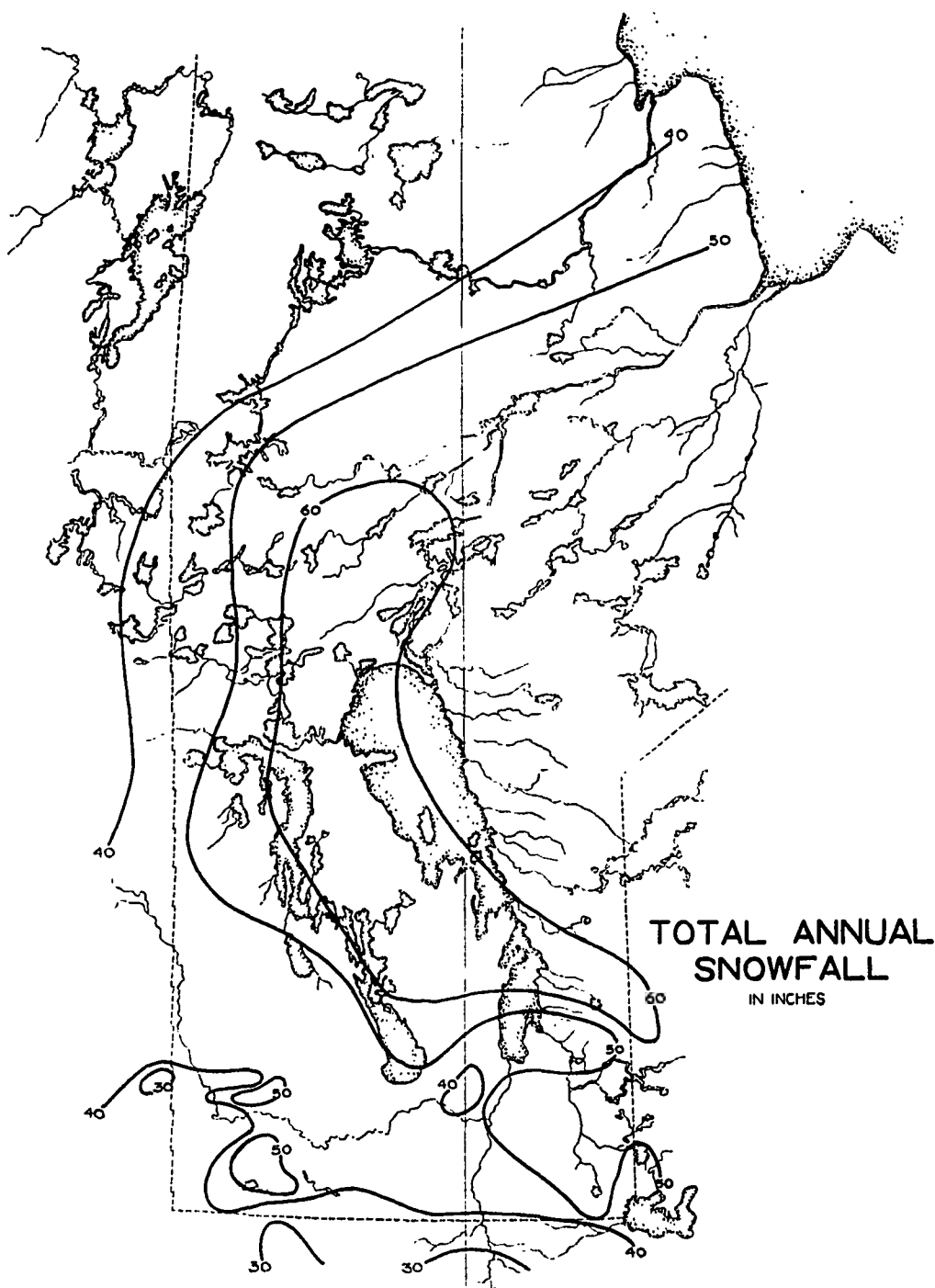
(61) Mapping the lengths of the period continuously frost-free, we see that the most favored region begins at the International Boundary between the Red and the Souris rivers and runs northward into the interlake region. From the confluence of the Qu'Appelle and Assiniboine rivers at St. Lazare northward to the region of Riding and Duck Mountains, the period is three weeks to a month shorter.



(62) Making the criterion of killing frost 29.5 F. we do not materially change the comparative advantages of districts as shown on map 61.

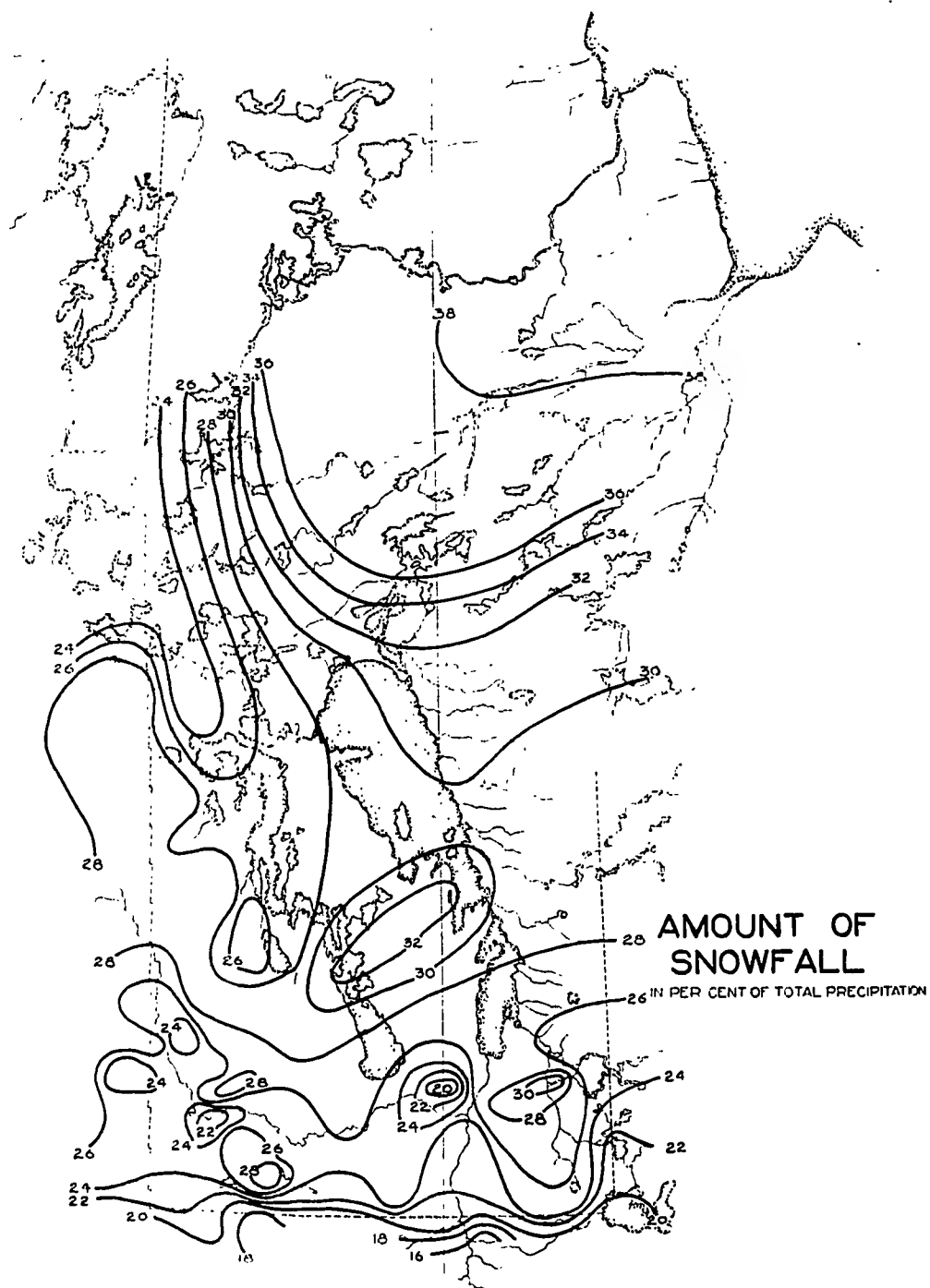


(63) The total annual precipitation is the sum of the rainfall and the water-equivalent of snowfall. There have been no measurements of the density of freshly-fallen snow in Manitoba, and there may be some error in assuming that ten inches of new snow average one inch of water. The heavier precipitation in the upper interlake region is somewhat doubtful on account of the shortness of the records.

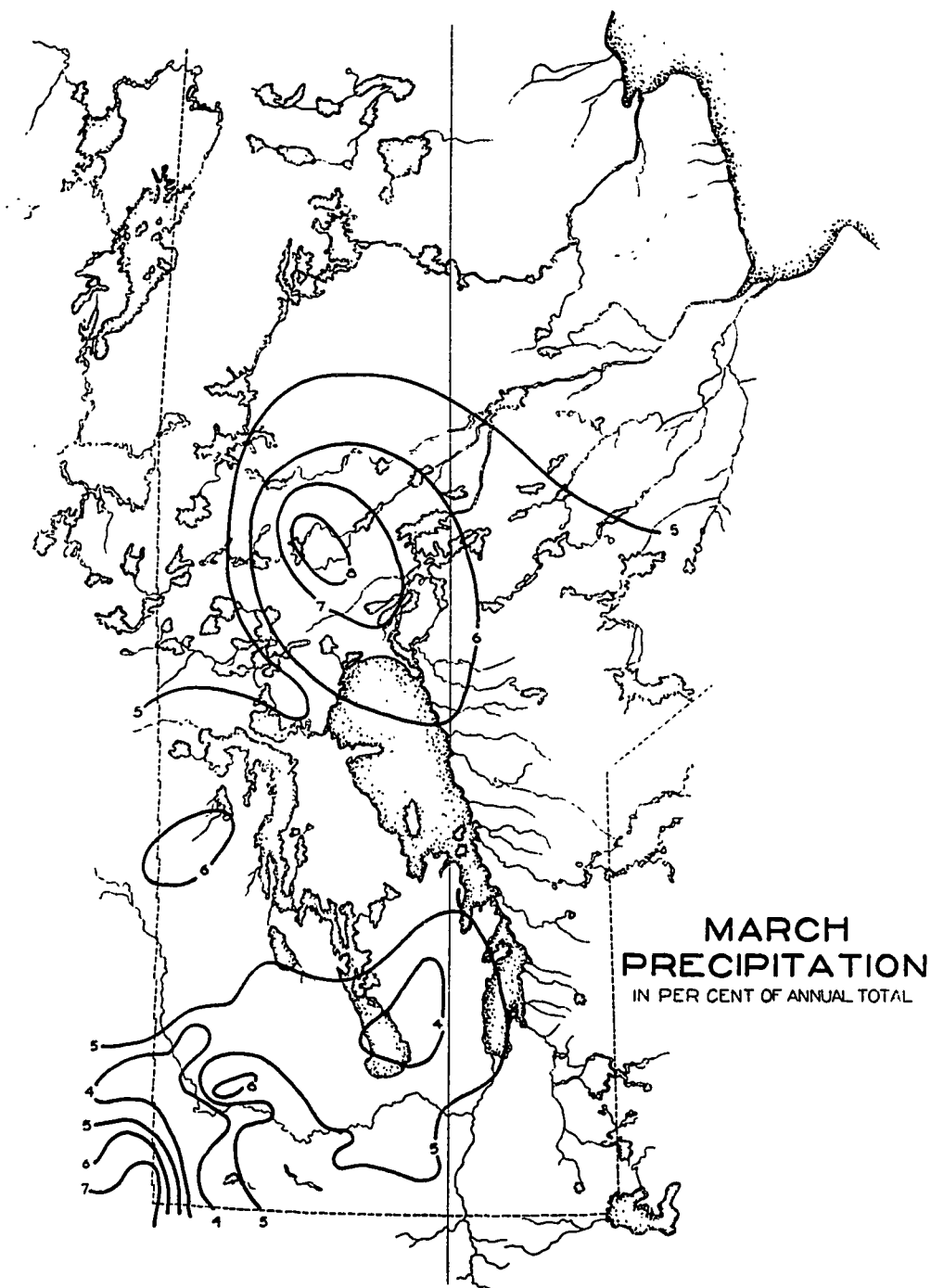


(64) Annual snowfall is greatest on the southwestern margin of the region of late, cold springs and early autumn cold-spells which lies immediately west of the Hudson Bay. Air warmed to the south and west may be expected to rise whenever convergence towards this cold region occurs. The chance that the resulting precipitation will be snow instead of rain is naturally high.

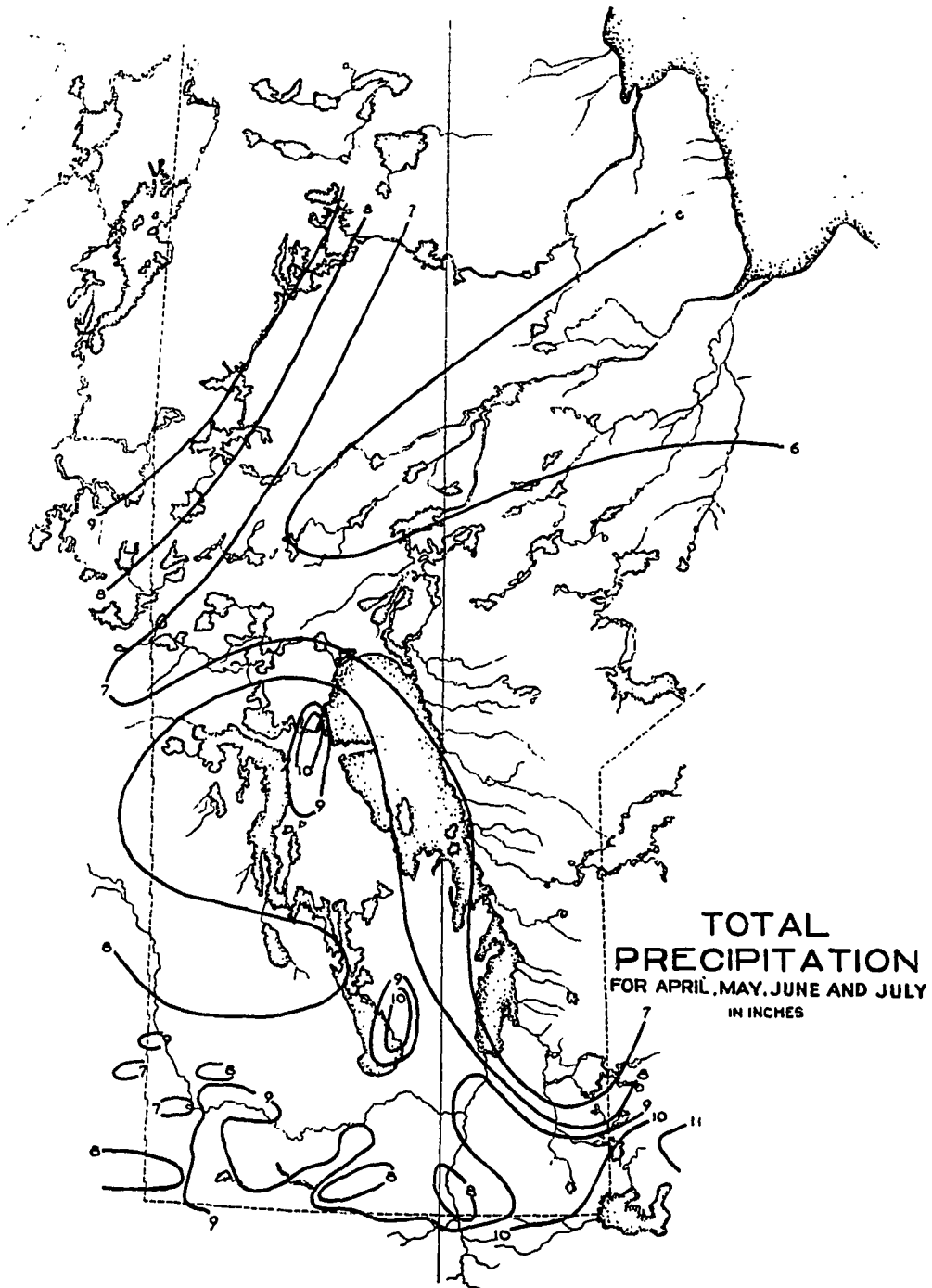
The principal effect of the lakes in this regard is probably to help delimit the western extension of the cold-summer territory surrounding Hudson Bay. Since air in the vicinity of the freezing-point has little power to pick up water-vapour from the lakes, they probably contribute very little in this manner towards the snowfall but no doubt favour formation of cold-fogs in this way especially in autumn.



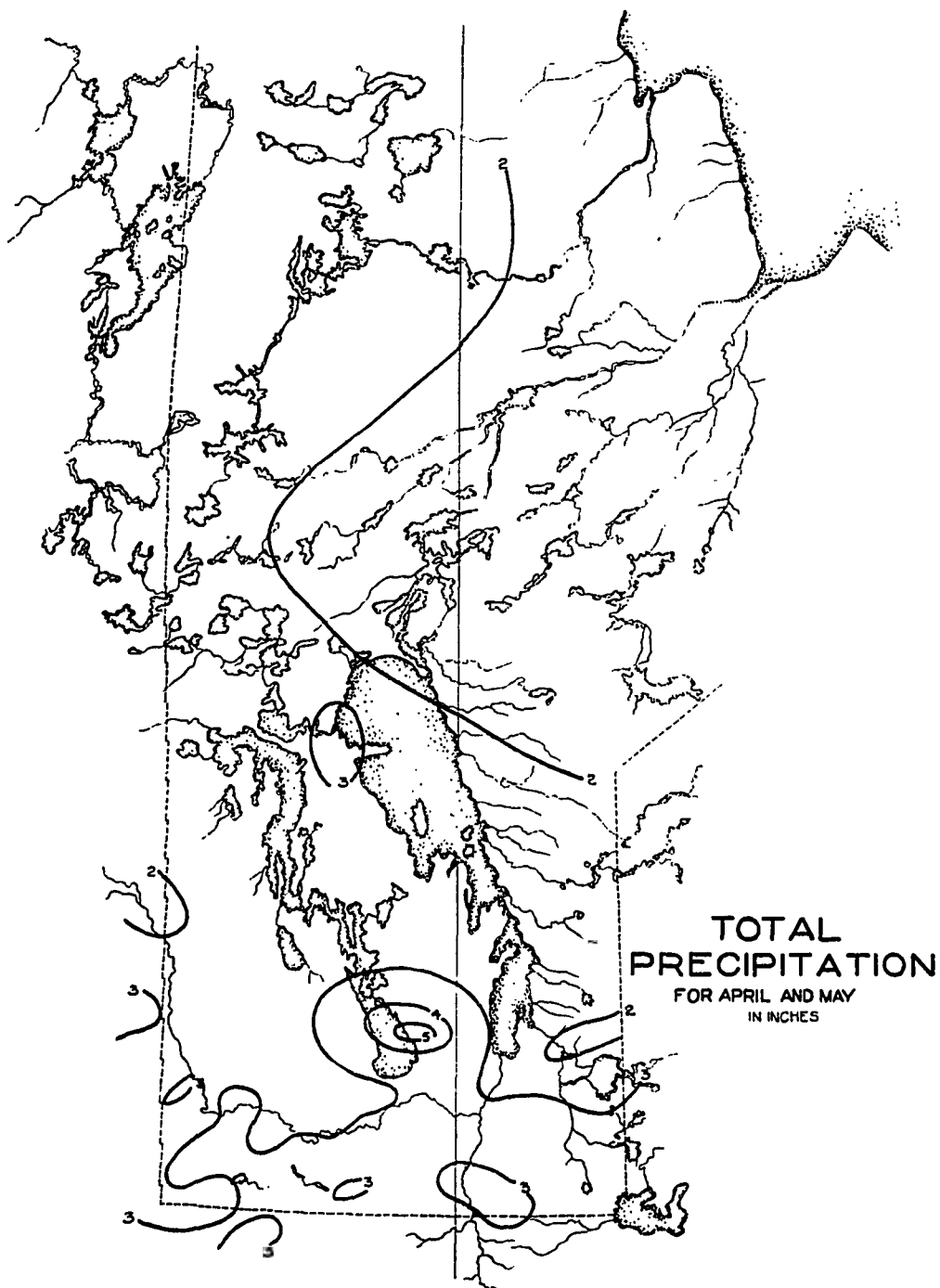
(65) The role played by the region of delayed summer-warmth around Hudson Bay in increasing the percentage of precipitation which falls as snow instead of rain, is well indicated by this map.



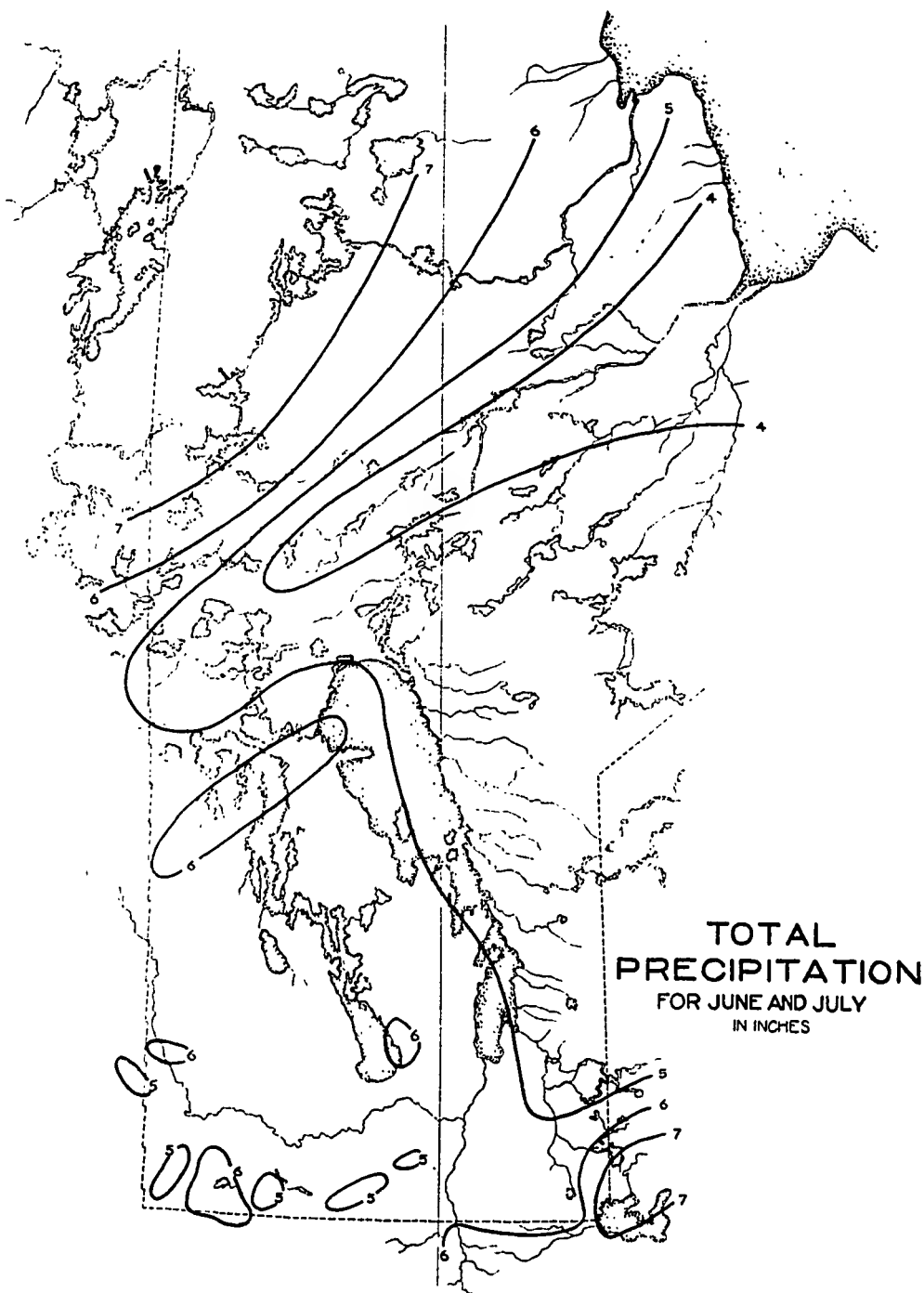
(66) In March barely five per cent of the annual precipitation falls. The great plains to the south have not yet experienced the summer monsoon which brings warm moist airmasses northward into the interior of the continent. Manitoba is usually dominated in March by dry, cold air which often blows with high velocity towards warmer regions.



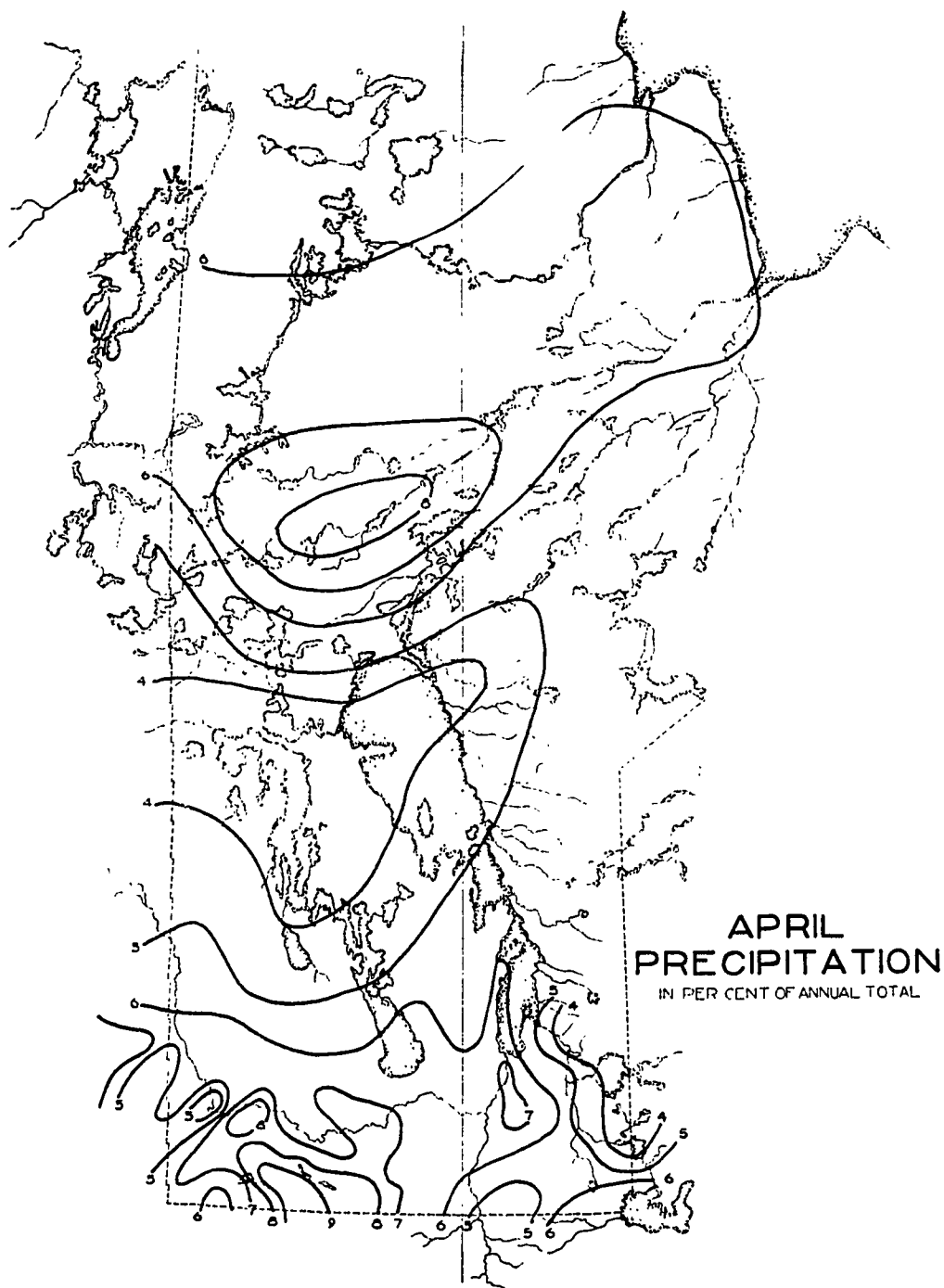
(67) The total precipitation from the beginning of April to the end of July (the usual season of growth for grain) is about nine inches over the cultivated region. This is about 1000 tons of water per acre. North and east of the great lakes the available data scarcely suffice to determine the average amount but it is likely to be a little more than six inches.



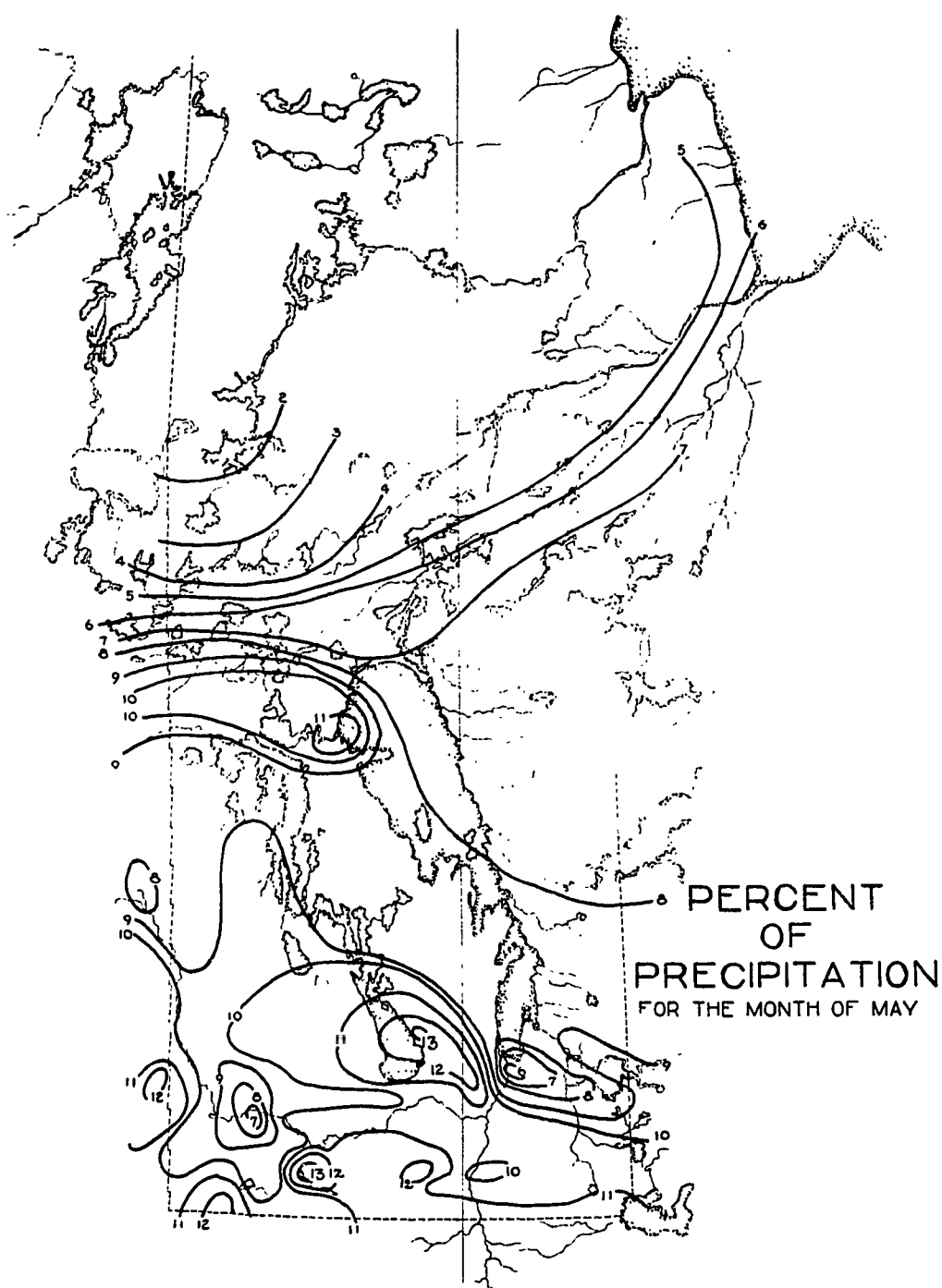
(68) In April and May precipitation averages little more than half of that in June and July. With good distribution it is, however, in a normal year ample for germination and early growth.



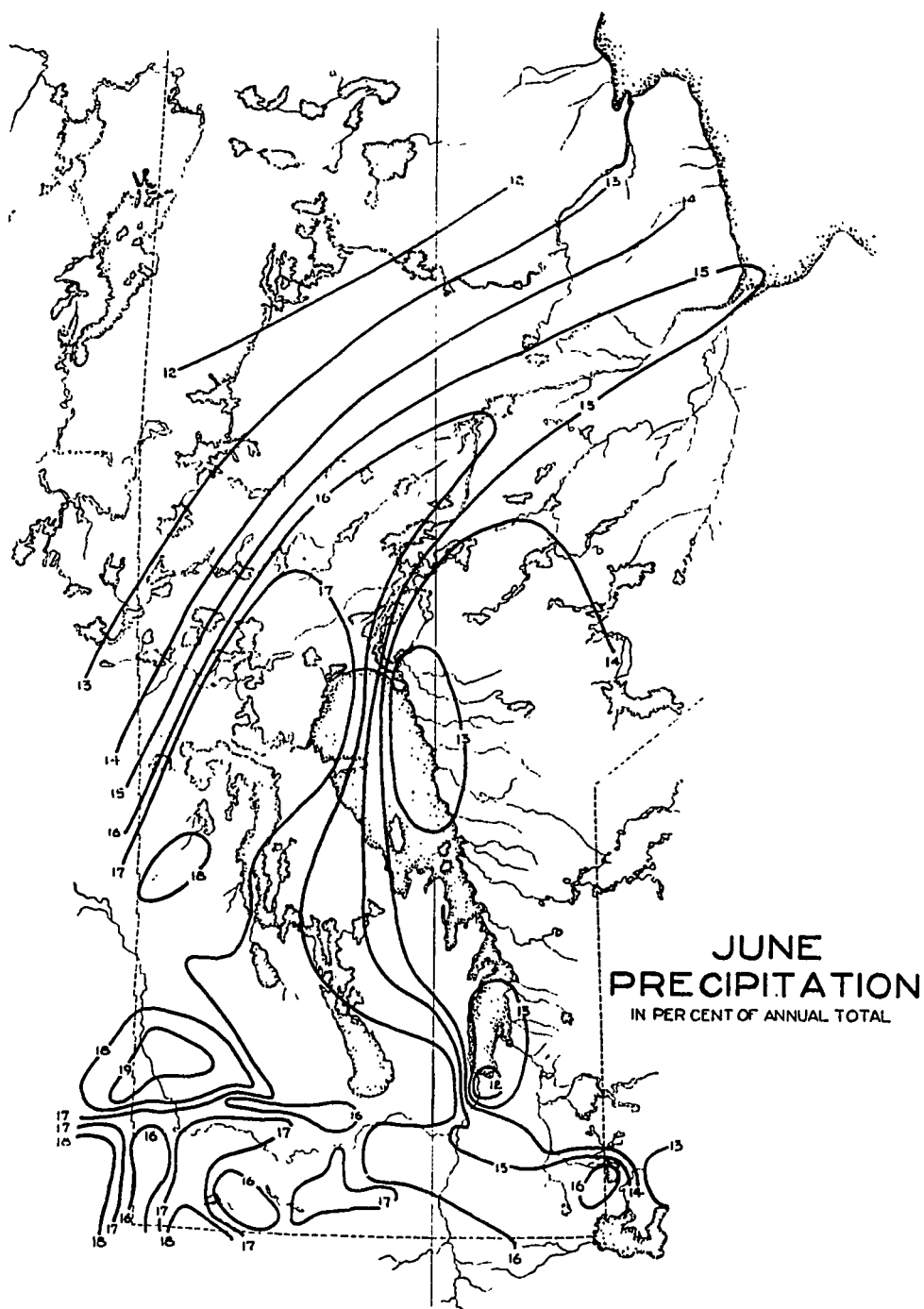
(69) Over the cultivated region we get on the average five to six inches of rain in the sixty-one days of June and July. This is about 600 tons of water per acre which is ample for vigorous growth of grain if well distributed throughout the period.



(70) If there were uniform distribution of precipitation throughout the year, about $8\frac{1}{2}$ per cent of the annual amount should be expected in April. Only a small portion of the province reaches this ratio in April. This month is therefore one of transition between the dry and the wet season.

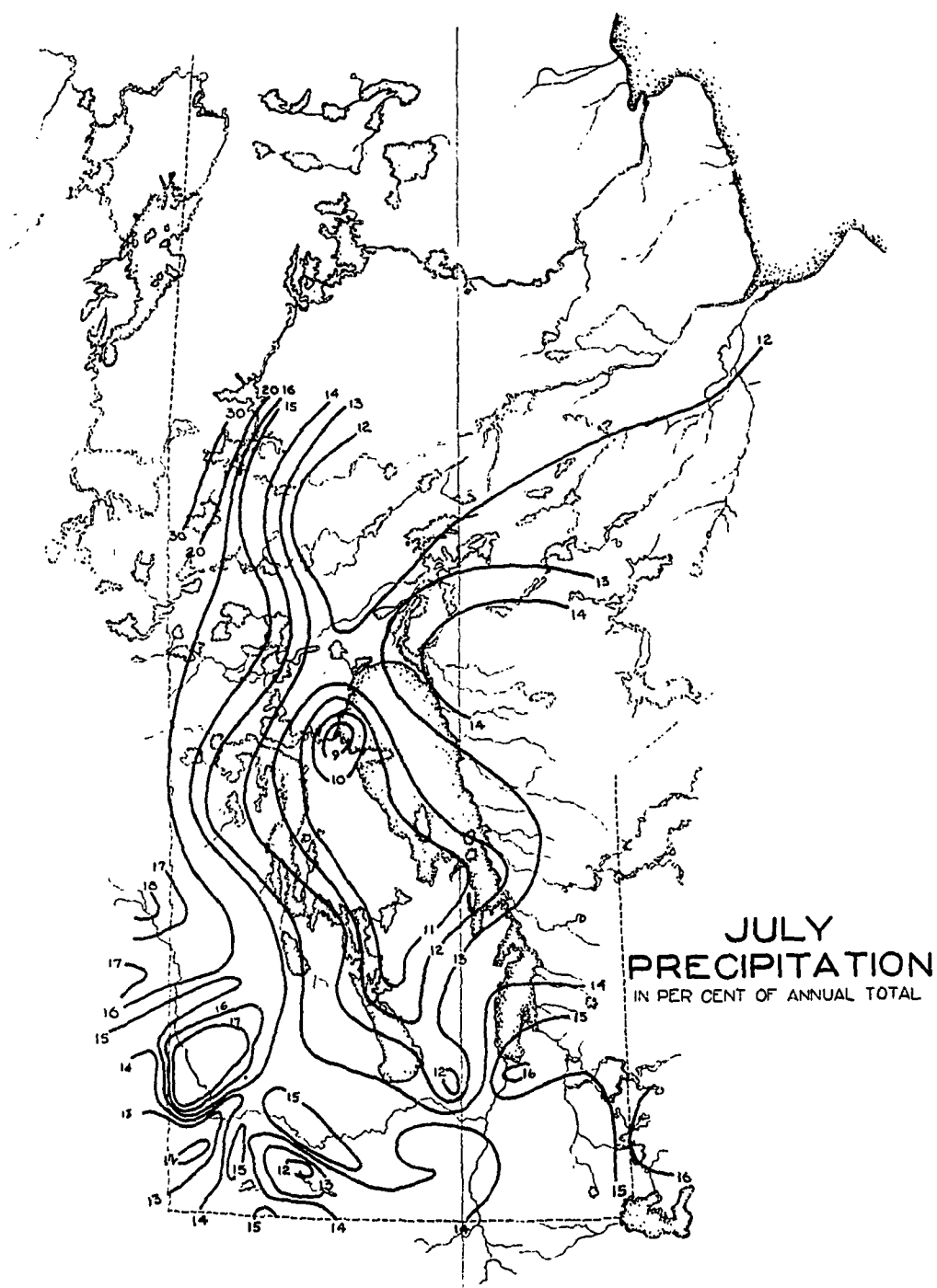


(71) The normally expected uniform percentage of $8\frac{1}{2}$ per month is exceeded in May in the south but the winter dry season is still in effect in the north.



(72) If there were uniform distribution of precipitation throughout the year, we should have $8\frac{1}{2}\%$ of the year's total in June. Since actually 16% to 18% is recorded on the average in this month, twice a uniform monthly rate, we see that Manitoba has a precipitation-peak in summer.

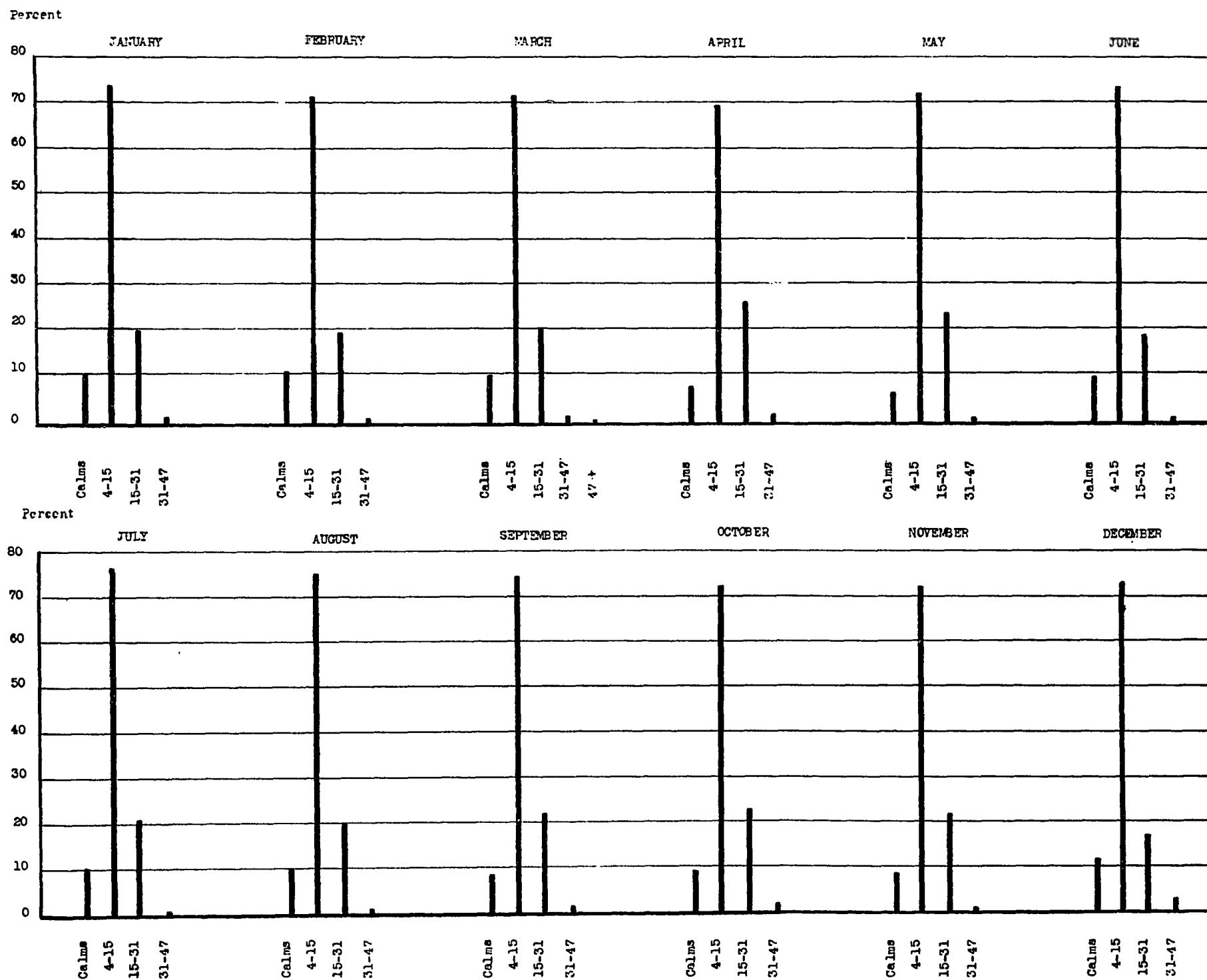
Reference to map 71 will draw attention to the rapid increase in the tendency toward precipitation in the region north of the lakes in June.



(73) In July the summer peak of precipitation is holding fairly steady in the agricultural region. The complexity of ratios in the southwest reflects the rather undependable character of rainfall in that region.

2

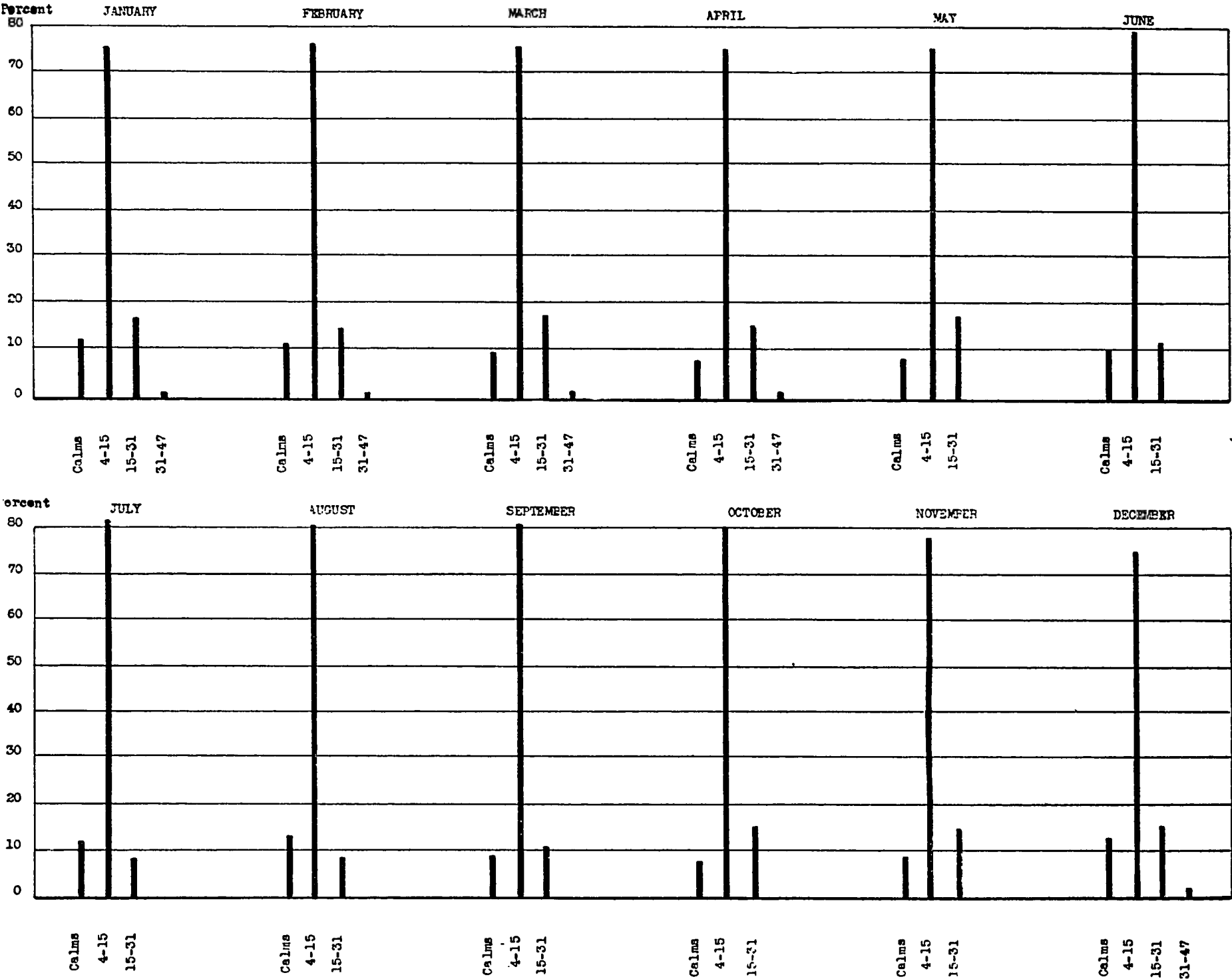
PERCENTAGE FREQUENCY
OF WINDS AT WINNIPEG
AT SPEEDS INDICATED IN MILES PER HOUR



(CHART 75)

PERCENTAGE FREQUENCY OF WINDS AT QU'APPELLE

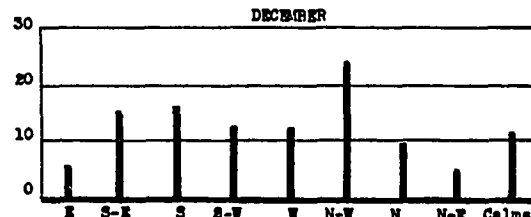
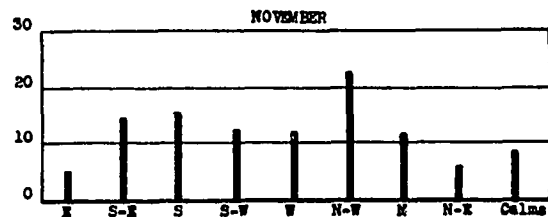
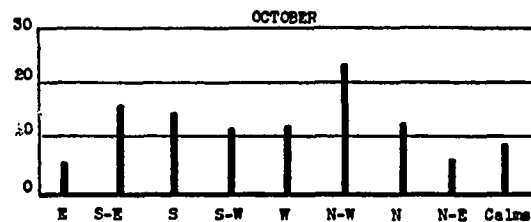
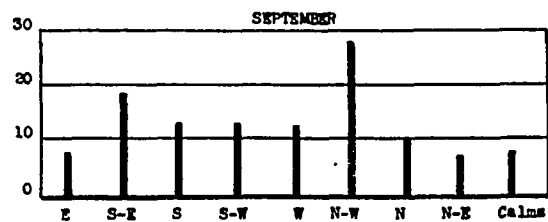
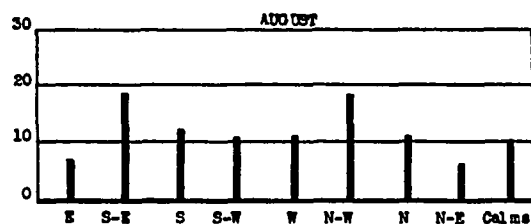
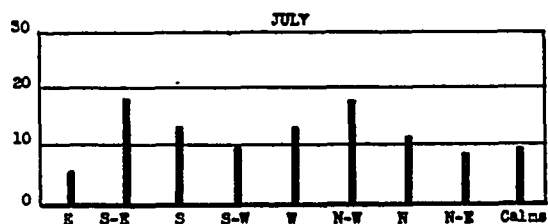
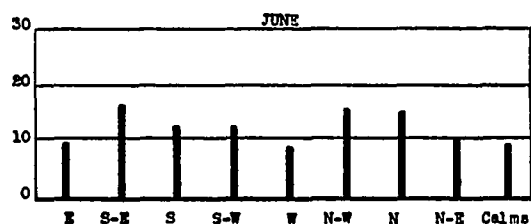
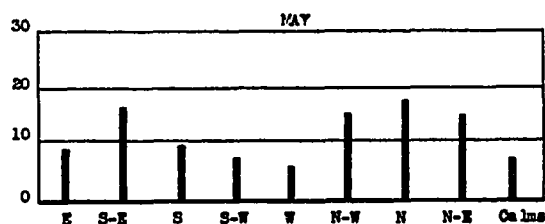
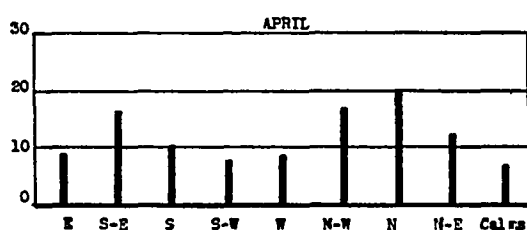
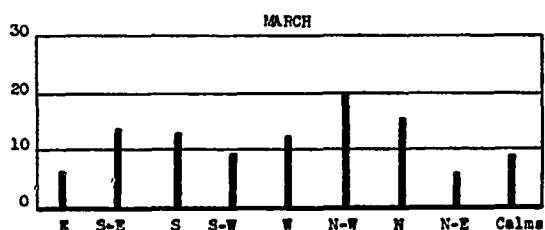
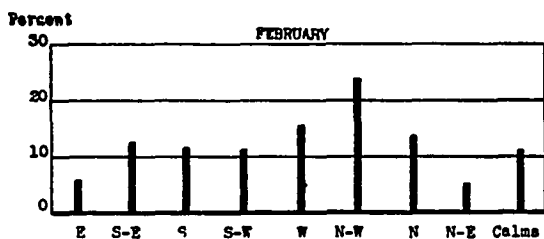
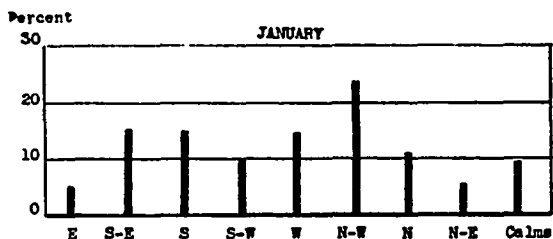
AT SPEEDS INDICATED IN MILES PER HOUR



(CHART 76)

PERCENTAGE FREQUENCY OF WINDS AT WINNIPEG

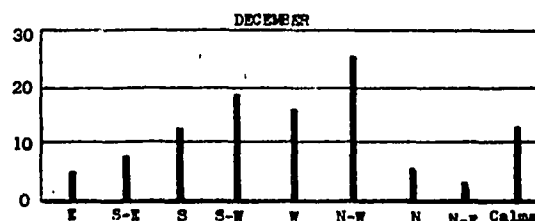
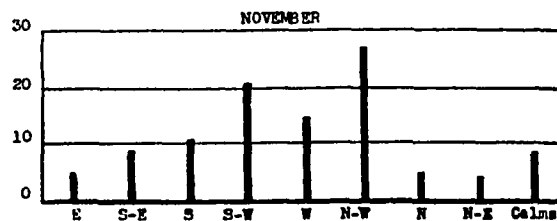
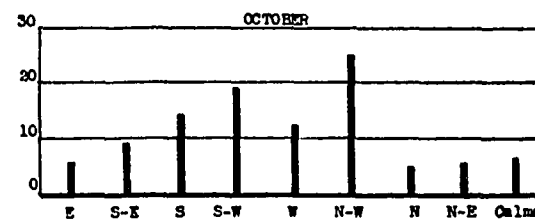
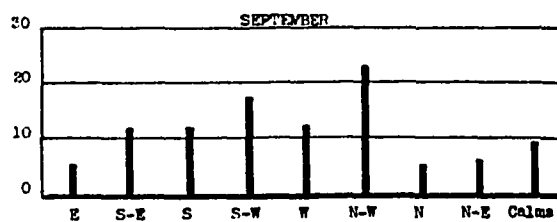
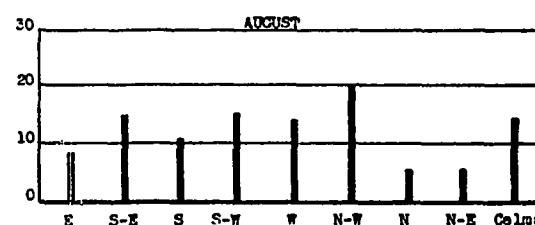
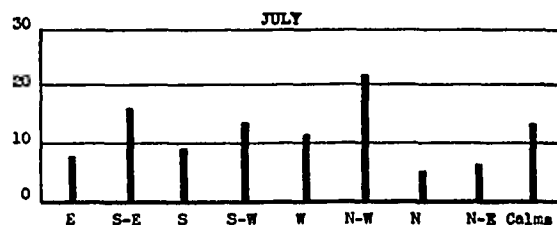
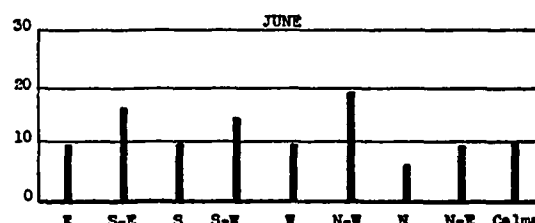
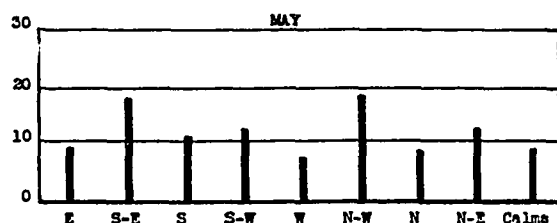
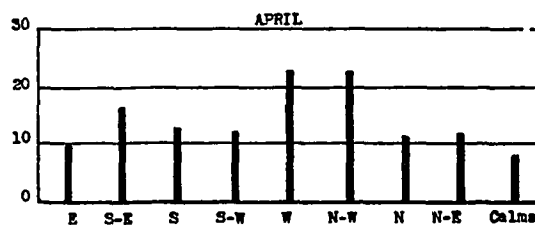
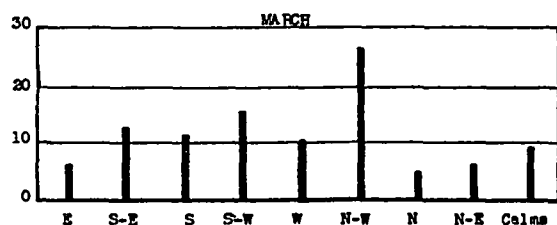
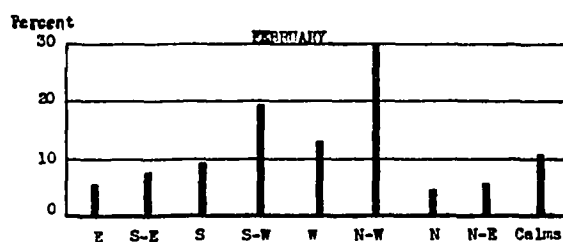
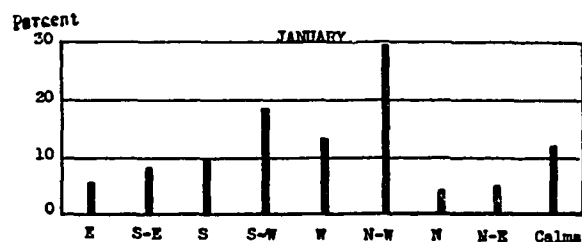
FROM DIRECTIONS INDICATED REGARDLESS OF SPEED



(CHART 77)

PERCENTAGE OF WINDS AT QU'APPELLE

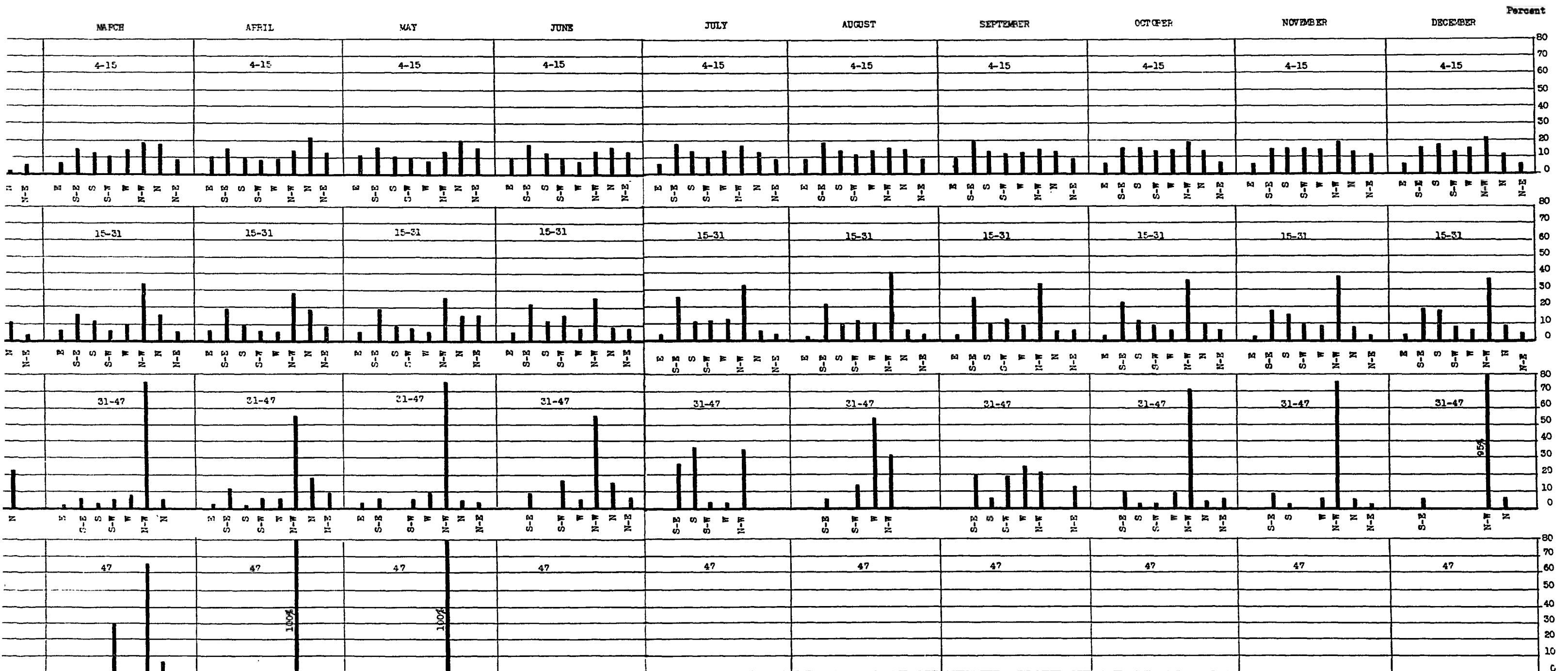
FROM DIRECTIONS INDICATED, REGARDLESS OF SPEED



PERCENTAGE FREQUENCY OF WINDS AT WINNIPEG

AT SPEEDS AND FROM DIRECTION AS INDICATED

2 of 2



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PERCENTAGE FREQUENCY OF WINDS AT QU'APPELLE

AT SPEEDS AND FROM DIRECTIONS INDICATED



PERCENTAGE FREQUENCY OF WINDS AT QU'APPELLE

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AT SPEEDS AND FROM DIRECTIONS INDICATED

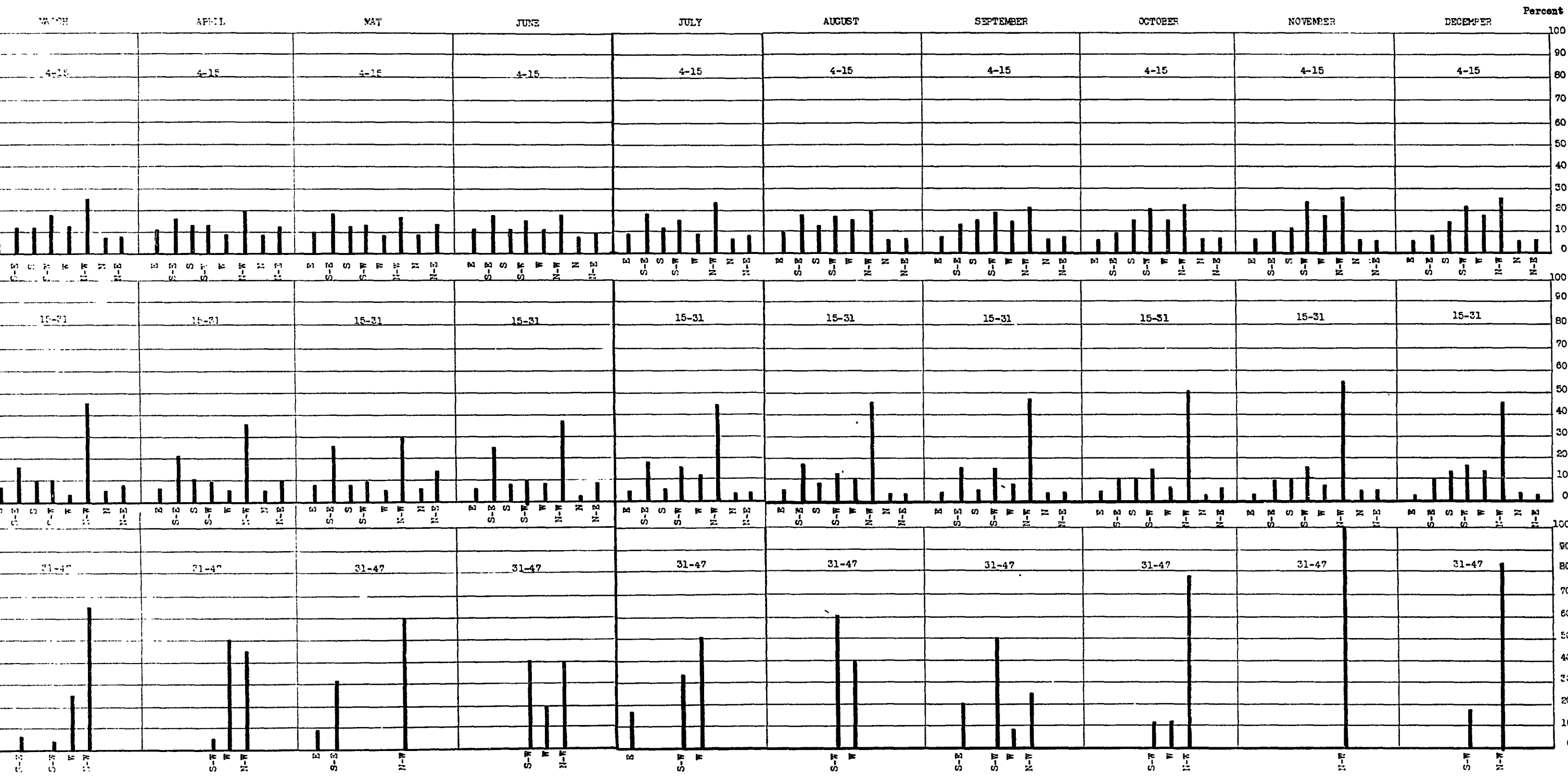


TABLE I

HISTORY OF FROSTS AT 33° F.

Place	LATE FROST				EARLY FROST			
	Average Date	Earliest Date	Latest Date	No. Years Reckoned	Average Date	Earliest Date	Latest Date	No. Years Reckoned
Norway House.....	160	133 (1913)	184 (1898)	31	250	215 (1912)	272 (1920)	32
Birtle.....	162	137 (1909)	187 (1934)	24	244	214 (1907)	268 (1919)	26
Boissevain.....	142	132 (1914)	156 (1912)	8	254	217 (1935)	279 (1931)	9
Brandon.....	156	130 (1902)	184 (1917)	45	243	201 (1898)	263 (1933)	44
Cypress River.....	156	132 (1933)	188 (1922)	32	251	221 (1923)	273 (1920)	31
Deloraine.....	172	156 (1935)	187 (1934)	2	236	236 (1934)	236 (1934)	1
Hamiota.....	163	148 (1928)	188 (1922)	15	241	197 (1918)	269 (1935)	13
Ninette.....	151	121 (1912)	184 (1917)	24	248	228 (1924)	286 (1914)	24
Portage la Prairie.....	142	112 (1922)	161 (1928)	32	262	229 (1917)	292 (1920)	32
Pierson.....	157	129 (1909)	197 (1912)	30	241	208 (1922)	262 (1927)	30
Rapid City (Forrest).....	156	140 (1936)	186 (1934)	9	249	235 (1934)	263 (1933)	9
Russell.....	159	130 (1902)	188 (1922)	26	233	197 (1905)	263 (1913)	26
Treesbank (St. Alban's).....	156	131 (1933)	183 (1927)	42	249	231 (1932)	275 (1921)	43
Souris.....	147	120 (1914)	172 (1917)	24	253	236 (1915 & 1934)	278 (1920)	22
Treherne.....	153	116 (1922)	188 (1908)	39	252	215 (1907)	276 (1921)	40
Virden.....	151	124 (1920)	187 (1922)	32	249	223 (1916)	269 (1933 & 1935)	33
Warren.....	147	114 (1927)	163 (1929)	9	251	226 (1929)	268 (1927)	9
Waskada.....	157	132 (1933)	187 (1934)	9	251	234 (1928 & 1934)	263 (1933)	9
Emerson.....	145	116 (1922)	168 (1926)	20	258	225 (1929)	298 (1920)	18
Graysville.....	156	136 (1904)	178 (1911)	33	252	225 (1916)	275 (1933)	31
Morden.....	145	116 (1922)	170 (1914)	32	263	238 (1915)	291 (1920)	32
Morden (Exp. Farm).....	145	116 (1922)	163 (1929)	19	263	244 (1918 & 1925)	276 (1921)	19
Morris.....	146	117 (1922)	171 (1916)	20	245	234 (1927)	280 (1921)	20
Oakbank.....	149	130 (1902)	172 (1917)	31	250	209 (1895)	276 (1921)	31
Swan Lake.....	154	135 (1914)	172 (1917)	13	251	237 (1928)	284 (1914)	12
Sprague.....	168	141 (1923)	192 (1926)	21	230	198 (1924)	251 (1926)	20
Berens River.....	158	137 (1922)	196 (1927)	29	244	198 (1927)	274 (1921)	26
Great Falls.....	143	134 (1933)	159 (1935)	9	266	242 (1931)	278 (1932)	9
Pinawa.....	156	135 (1920)	193 (1926)	20	250	218 (1924)	276 (1921)	21
Dauphin.....	147	131 (1933)	169 (1926)	30	256	236 (1923 & 1927)	279 (1921)	31
Aitkensville.....	153	124 (1936)	186 (1915)	21	248	203 (1912)	277 (1914)	22
Flin Flon Mine.....	149	137 (1933)	165 (1928)	9	258	213 (1928)	279 (1931)	9
Oak Lake.....	156	149 (1928)	163 (1929)	2	255	248 (1929)	261 (1928)	2
The Pas.....	155	128 (1919)	193 (1926)	24	247	198 (1924)	269 (1917)	24
Winnipeg.....	150	123 (1896)	182 (1879)	62	256	232 (1895)	290 (1920)	63
Minnedosa.....	156	125 (1896)	184 (1917)	54	243	216 (1889)	268 (1919)	54
Alameda.....	157	137 (1896)	180 (1895 & 1905)	9	229	200 (1898)	253 (1894)	11
Broadview.....	152	127 (1922)	195 (1906)	11	246	226 (1908)	257 (1922 & 1936)	9
Crescent Lake.....	158	142 (1914)	178 (1911)	12	239	214 (1915)	259 (1912)	13
Cumberland House.....	150	131 (1928)	174 (1929)	11	257	243 (1911)	267 (1928)	11
Estevan.....	149	133 (1914 & 1935)	177 (1904)	24	254	228 (1910)	273 (1920)	21
Grenfell.....	154	120 (1896)	190 (1919)	36	245	201 (1898)	269 (1933)	37
Kamsack.....	162	139 (1923)	188 (1934)	26	236	210 (1926)	270 (1933)	22
Moosomin.....	149	133 (1934)	164 (1900)	17	247	226 (1908)	269 (1906)	17
Whitewood.....	154	126 (1922)	187 (1934)	21	242	206 (1918)	268 (1919)	23
Yorkton.....	150	133 (1922)	178 (1935)	26	247	206 (1918)	265 (1932)	26

N.B.—Dates are yeardays.

TABLE II

HISTORY OF FROSTS AT 29.5° F.

Place	LATE FROST				EARLY FROST			
	Average Date	Earliest Date	Latest Date	No. Years Reckoned	Average Date	Earliest Date	Latest Date	No. Years Reckoned
Norway House	147	136 (1928)	160 (1936)	8	256	230 (1928)	271 (1930)	8
Birtle	145	116 (1922)	187 (1934)	20	258	236 (1928)	277 (1920)	22
Boissevain	136	126 (1936)	149 (1930)	3	270	263 (1934)	279 (1931)	4
Brandon	146	117 (1922)	172 (1917)	26	259	237 (1928)	277 (1920)	21
Cypress River	139	110 (1935)	172 (1917)	25	268	236 (1915)	290 (1920)	27
Deloraine	147	133 (1934)	156 (1935)	3	252	237 (1934)	266 (1927)	2
Hamiota	148	124 (1932)	188 (1922)	14	255	236 (1931)	270 (1933)	13
Ninette	136	113 (1927)	163 (1929)	23	264	245 (1917)	289 (1931)	22
Portage la Prairie	132	110 (1922)	144 (1930)	16	276	256 (1923)	302 (1920)	14
Pierson	139	119 (1935)	172 (1917)	28	254	212 (1933)	278 (1922)	27
Rapid City (Forrest)	141	139 (1933)	158 (1931)	15	261	246 (1930)	281 (1922)	15
Russell	144	123 (1916 & 1920)	167 (1915)	27	251	204 (1896)	268 (1919)	30
Treesbank (St. Alban's)	142	125 (1908)	163 (1929)	31	262	238 (1915)	286 (1914)	31
Souris	136	113 (1927)	157 (1935)	24	265	245 (1917)	306 (1924)	23
Treherne	142	113 (1927)	172 (1905)	30	267	250 (1901)	302 (1920)	29
Virden	136	113 (1927)	173 (1906)	30	262	233 (1907)	282 (1920 & 1922)	30
Warren	153	138 (1932)	163 (1929)	5	267	256 (1929)	281 (1931)	5
Waskada	144	131 (1927)	163 (1929)	12	258	236 (1928 & 1934)	269 (1933 & 1935)	12
Emerson	133	108 (1922)	163 (1929)	18	276	255 (1929)	301 (1929)	17
Graysville	141	114 (1927)	170 (1914 & 1922)	29	263	238 (1915)	279 (1928)	28
Morden	137	114 (1927)	159 (1924)	30	273	238 (1915)	309 (1931)	27
Morden (Exp. Farm)	134	115 (1927)	159 (1924)	19	270	252 (1918)	309 (1931)	19
Morris	135	113 (1927)	162 (1929)	20	269	252 (1918)	285 (1921)	20
Oakbank	136	114 (1927)	160 (1915)	26	264	238 (1915)	286 (1914)	24
Swan Lake	137	123 (1920)	154 (1917)	13	272	246 (1918)	317 (1914)	13
Sprague	149	115 (1916)	197 (1920)	21	243	229 (1924)	261 (1936)	21
Berens River	146	117 (1922)	195 (1927)	27	265	226 (1929)	308 (1921)	26
Great Falls	134	120 (1935)	144 (1924 & 1930)	14	279	261 (1929)	308 (1931)	12
Pinawa	144	118 (1922)	163 (1929)	20	270	248 (1924)	287 (1922)	21
Dauphin	138	115 (1922)	152 (1929)	24	272	255 (1923)	291 (1920)	26
Aitkensville	146	126 (1919)	186 (1915)	20	259	238 (1915)	287 (1931)	21
Flin Flon Mine	140	121 (1935)	165 (1928)	9	263	242 (1928)	283 (1933)	9
Oak Lake	136	126 (1927)	142 (1929)	3	259	249 (1929)	268 (1927)	3
The Pas	140	125 (1916 & 1919)	157 (1923)	23	259	220 (1926)	284 (1931)	23
Winnipeg	137	113 (1927)	158 (1888)	30	270	249 (1881)	304 (1934)	31
Minnedosa	143	114 (1927)	163 (1900 & 1929)	29	260	234 (1920)	281 (1922)	25
Broadview	141	110 (1922)	195 (1906)	10	259	240 (1911)	278 (1921)	9
Cumberland House	137	124 (1926)	149 (1921)	12	265	256 (1923)	275 (1922)	11
Estevan	135	111 (1904)	159 (1921)	22	264	247 (1919)	284 (1913)	22
Grenfell	144	123 (1922)	172 (1917)	20	258	236 (1934)	275 (1921)	20
Kamsack	153	115 (1922)	188 (1934)	25	250	224 (1916)	279 (1933)	23
Moosomin	138	123 (1934)	152 (1910)	12	264	253 (1910)	275 (1921)	13
Whitewood	141	117 (1922)	171 (1931)	21	258	244 (1930)	273 (1920)	22
Yorkton	140	122 (1926)	167 (1915)	28	258	243 (1910)	276 (1921)	26

TABLE III

RAINFALL OF GROWING SEASON

Year	Winnipeg	Birtle	Minnedosa	Oakdale	Portage la Prairie	Russell	Souris	Grenfell
1874	10.16							
1875	9.22							
1876	11.32							
1877	15.60							
1878	17.20							
1879	17.22							
1880	12.59							
1881	6.36							
1882	10.06							
1883	7.62	10.44	5.58	5.92	7.98	6.63	5.18	
1884	7.85	13.00	7.99	8.78	6.56	6.20	5.06	6.51
1885	9.46		9.79	15.58	11.51	14.85	10.11	6.55
1886	4.79		6.86	8.17	6.16	7.36	5.16	6.51
1887	9.11		12.16	14.40	11.06	11.44	9.37	9.00
1888	8.45		19.00	11.25	11.30	11.96	8.55	7.58
1889	5.47		4.87	4.73	5.09	3.95		5.26
1890	11.37		9.94	13.68	10.46	7.69		12.87
1891	8.71		9.07	16.51	13.76	7.27		12.49
1892	9.37		6.57	14.05	13.13	7.28		9.70
1893	13.82		5.62	11.22	12.43	9.97		
1894	7.17		6.66	7.43	7.98			5.28
1895	9.97		9.14	13.21	11.62			8.47
1896	16.93		12.33	12.21	16.11	11.86		11.45
1897	10.29		5.54	4.81	7.05	5.04		3.76
1898	9.74		8.30	7.86	6.93	6.13		5.20
1899	10.01		8.78	12.73	6.80	7.25		4.82
1900	6.32		6.13	5.08	4.62	3.24		
1901	15.48		12.43	20.96	8.54	9.75		8.35
1902	9.79		11.69	9.20	7.79	9.50		7.64
1903	7.48		10.13	6.82	5.77	6.13		6.85
1904	12.00	6.13	9.67	6.66	11.18	5.23		9.03
1905	12.57	6.75	8.30	10.56	10.43	6.22		7.36
1906	14.28	10.15	12.29	15.00	11.53	9.09		12.21
1907	7.48	6.39	8.38	7.55	5.76			9.86
1908	9.63	6.47	9.28		6.19			5.37
1909	8.21	8.95	8.08		8.91			12.75
1910	6.25		6.76		7.77			11.57
1911	14.18		8.59		13.68			9.21
1912	12.86	3.33	8.59		11.66	8.81		9.71
1913	6.30		8.21		6.31	9.78	4.25	10.39
1914	11.00		8.41		8.12	7.33	6.29	11.60
1915	6.52		9.00		7.92	8.64	6.89	8.92
1916	9.73		10.49			10.33	10.53	8.61
1917	5.65		3.29		13.59	5.52	5.34	8.16
1918	7.86		6.64				9.39	6.88
1919	11.80		8.63				8.91	8.58
1920	5.97		7.58				4.90	8.29
1921	8.89		7.50				7.10	12.62
1922	10.40	10.57	9.17			8.23	8.50	11.66
1923	8.30	11.25	12.97			10.76	8.87	14.69
1924	8.04	8.43	9.61			6.75	11.19	
1925	4.39	7.18	6.97			7.66	7.27	
1926	6.53	5.31	5.16			6.76	7.19	
1927	10.06	9.46	10.55			7.81	13.20	8.83
1928	12.55	7.41	10.74			8.63	10.60	11.27
1929	6.29	4.61	4.95			6.08	6.58	6.44
1930	12.41	11.12	7.77			8.19	8.71	8.00
1931	6.98	5.03	5.02			4.32	6.67	3.42
1932	7.17	14.30	9.64			8.21	9.94	8.70
1933	6.99	0.94	8.76			6.96	8.27	8.70
1934	7.43	4.69	6.11			4.63	5.56	4.68
1935	8.97	14.34	14.57			11.82	18.45	11.93
Average	9.62	8.42	8.52	10.57	9.29	7.89	8.21	8.68
S. D.	3.10	3.11	2.33	4.14	2.93	2.43	2.90	2.65

TABLE III (Continued)

RAINFALL OF GROWING SEASON

Year	Brandon	Morden	Ninette	Oakbank	Rapid City	Swan Lake	Treherne	Treesbank (St. Alban's)
1884	4.30							
1885	9.80	9.69	10.60	9.57	9.05	14.03	10.18	10.71
1886	7.63	4.35	6.80	4.02	8.27	7.67	5.73	6.28
1887	16.95	9.40		10.45	14.69	15.82	14.07	12.58
1888	5.41	5.91		12.89	10.21	8.99	8.91	10.80
1889	4.32	6.55		5.85	4.07	5.71	4.92	5.62
1890	8.01	6.77		11.22	12.45	13.27	11.18	9.91
1891	10.52	10.95		10.23	8.76	10.48	12.89	11.03
1892	7.03	10.26		11.13	7.28	13.29	14.38	10.09
1893	4.80	10.30		12.81	4.27	10.16	11.71	6.31
1894	3.89	6.96		9.90	5.89	10.00	9.77	8.93
1895	8.89	7.92		10.14	8.83	15.45	14.02	9.62
1896	12.39	18.14		17.34	12.76	17.94	18.96	12.42
1897	2.97	11.03		10.70	4.54	7.97	4.89	4.77
1898	9.63	9.40		10.15	4.60	9.43	7.76	6.03
1899	8.17	10.78		9.70	10.67	11.30	10.55	12.77
1900	4.07	3.01		5.77	4.48	6.52	4.90	4.74
1901	13.27	11.41		12.35	13.21	10.47	9.95	13.61
1902	14.66	8.80		9.07	12.04	9.77	8.14	8.36
1903	7.55	5.19		7.66	7.48	6.19	7.12	8.49
1904	7.40	16.20		12.57	7.19	10.56	12.95	7.90
1905	11.23	11.56		11.86	7.16	9.55	7.81	11.86
1906	10.91	17.74		11.00	10.32	8.84	3.95	6.33
1907	8.76	4.97		8.40	7.47	5.53	4.19	5.53
1908	8.57	8.59		9.69	8.10	8.22	7.66	8.00
1909	9.46	11.28		6.66	7.06	8.59	9.14	8.71
1910	5.69	5.15		7.18	6.82	6.53	10.52	8.21
1911	7.86	7.50		17.47	11.43	10.77	12.97	10.50
1912	11.20	8.65		11.81	11.37	13.15	12.90	11.53
1913	5.43	2.95		6.16	5.59	4.57	6.21	6.29
1914	8.91	5.75	5.20	9.96	8.63	7.72	8.10	8.56
1915	8.50	6.44		5.58	8.15	9.02	9.02	8.45
1916	9.47	5.58	9.19	9.44	8.98	9.35	11.21	8.54
1917	4.25	7.22	5.86	8.03	2.41	4.56	5.26	4.67
1918	6.50	8.67	6.90	8.73	5.68	7.45	8.05	6.45
1919	8.84	10.53	7.65	11.03	9.67	6.83	9.33	12.14
1920	5.65	5.86	5.81	4.59	7.28	9.86	8.90	7.20
1921	9.44	10.78	5.74	10.18	6.64	10.85	13.00	7.26
1922	7.17	7.94	9.07	10.78	7.86		9.00	9.32
1923	10.57	3.81	8.79	7.65	6.28		7.16	10.71
1924	11.71	7.49	9.60	10.19	7.39		12.18	9.88
1925	7.97	8.33	9.81	7.87	8.56	7.16	8.25	8.97
1926	6.40	8.89	7.79	5.84	4.17	7.06	9.00	13.70
1927	13.05	12.50	17.61	9.70	11.89	11.91	12.84	11.96
1928	13.06	16.44	9.26	14.05	12.00	9.99	11.11	12.74
1929	7.75	3.30	7.25	3.99	5.51	2.40	6.36	6.50
1930	13.66	8.70	9.66	10.86	12.02		6.45	10.48
1931	8.84	4.28	6.86		6.08		1.70	7.71
1932	13.82	7.30	9.80		9.29		9.67	7.98
1933	6.69	8.00	9.25		7.99		8.17	10.62
1934	4.85	5.11	5.30		4.22		4.68	4.12
1935	16.25	11.18	15.42		11.08		15.63	15.52
Average	8.73	8.54	8.66	9.61	8.19	9.40	9.49	9.04
S. D.	3.26	3.54	2.99	2.92	2.79	3.15	3.23	2.66

TABLE III (Concluded)

RAINFALL OF GROWING SEASON

Year	Berens River	Norway House	Deloraine	Swan River	Dauphin	Cypress River	Pierson	Virden	Moose Horn Bay (Aitkensville)	The Pas	Pinawa	Sprague
1887	8.61											
1888	4.42											
1889	5.74											
1890	3.72											
1891												
1892	4.41											
1893	9.93											
1894	8.50											
1895	9.03											
1896	9.29	10.64										
1897	6.34	10.85	6.79									
1898	8.34	3.77	5.56									
1899	6.84	8.48	12.65									
1900	7.30	5.92	6.16									
1901	10.73	11.18	20.45	11.22								
1902	5.80	6.44	7.62	13.64								
1903	3.98	8.61	22.11	13.64	11.75							
1904	2.42	8.42	3.28	9.52	4.94	7.26	2.69	8.27				
1905	2.90	6.06	8.36		6.85	10.93	5.74	16.20				
1906		5.37			14.32	11.28		16.53				
1907		6.89			5.90	5.47	4.54	5.71				
1908	7.61	6.07		6.68		8.36	7.13	5.10				
1909	6.91	8.10	9.83	6.71		7.39	8.92	5.60				
1910	7.48	1.57	3.38	8.77		7.37	4.33	4.38	6.47			
1911	10.55	4.46	1.32	9.13	9.15	10.95	6.63	6.41	9.89	10.75		
1912	4.40	7.09	10.93		10.34	12.21	8.61	3.32	7.70	6.66		
1913	5.82	3.51			6.83	6.68	6.43	3.44	7.07	7.91		
1914	4.10	2.70	9.63		4.69	6.97	13.69	5.75	5.94	7.17		
1915	9.91	5.54	7.94	9.30	15.93	9.63	6.74	6.73	5.49	5.08	5.92	
1916	6.72	6.20	10.57	8.14	9.52	7.88	10.13	9.11	10.49	8.95	11.10	5.66
1917	5.76	7.50	6.78	6.35	7.36	6.31	4.50	4.55	7.71	5.11	8.95	4.98
1918	8.93	7.46		6.98	5.34	8.38	5.35	7.09	7.73	7.73	9.02	7.79
1919	4.83			6.02	7.56	6.81	7.65	6.06	7.27	5.23	10.20	5.98
1920	3.46	3.70			5.57	8.49	6.08	4.85		2.55	4.60	5.80
1921	4.56	8.60		9.77	8.12	8.06	6.63	5.37		3.60	10.57	6.22
1922	7.57	8.81		5.65	5.69	9.65	6.80	6.81		6.19	10.68	9.58
1923	8.40	6.14		8.59	8.37	3.75	11.13	7.61		4.83	5.90	8.77
1924	8.78	5.03		4.03	5.04	5.65	13.17	7.69		6.06	6.01	13.06
1925	9.83	7.80		9.09	7.75	9.23	7.13	5.69	9.40	8.94	4.36	13.05
1926	5.34	4.48	9.63	2.89	4.39	6.86	9.10	7.32	3.24	5.54	3.52	8.55
1927	9.58	4.29			6.91	14.11	15.50	8.95	11.87	4.90	5.13	13.50
1928	4.76	6.81			6.60	11.42	10.35	8.17	9.63	5.08	7.01	14.52
1929	4.06	2.30			3.49	6.68	6.80	7.14		3.56	3.27	6.96
1930	6.36	1.83			6.84	9.63	4.21	10.35	10.20	11.02	6.46	12.96
1931	4.28	2.90			4.11	6.19	2.63	5.61	7.82	5.53	4.37	6.70
1932	7.18	2.96			9.36	11.36	7.01	7.60	8.69	8.42	3.55	11.41
1933	6.81				7.40	7.71	6.65	7.61	8.44	4.52	3.01	5.37
1934	6.78	4.93	3.87		4.92	5.49	3.52	4.23	6.21	9.84	4.72	6.81
1935	8.06	4.63	18.06		14.78	16.98	17.83	14.40	11.49	6.93	4.78	7.33
Average	6.66	6.00	9.25	8.22	7.66	8.60	7.67	7.30	8.14	6.48	6.34	8.75
S.D.	2.18	2.45	5.43	2.73	3.09	2.73	3.59	3.16	2.10	2.20	2.61	3.09

TABLE IV

PRECIPITATION—ANNUAL AND SEASONAL EXTREMES

	CONSECUTIVE YEARS					CONSECUTIVE GROWING SEASONS				
	1	2	3	4	5	1	2	3	4	5
Winnipeg (1874-1937)										
Driest.....	11.66	30.50	46.33	62.99	83.81	4.39	10.92	18.96	27.26	36.22
Date.....	1886	1924-25	1924-26	1886-89	1886-90	1925	1925-26	1924-26	1923-26	1932-36
Wettest.....	31.91	60.66	88.97	113.07	135.80	17.22	34.42	50.02	62.61	73.93
Date.....	1877	1877-78	1877-79	1876-79	1876-80	1879	1878-79	1877-79	1877-80	1876-80
Winnipeg (1884-1937)										
Driest.....	11.66	30.50	46.33	62.99	83.81	4.39	10.92	18.96	27.26	36.22
Date.....	1886	1924-25	1924-26	1886-89	1886-90	1925	1925-26	1924-26	1923-26	1932-36
Wettest.....	27.78	48.13	68.78	88.91	108.99	16.93	27.22	38.85	46.97	58.18
Date.....	1901	1927-28	1899-1901	1890-93	1901-05	1896	1896-97	1904-06	1896-99	1893-97
Minnedosa (1884-1937)										
Driest.....	9.85	24.80	34.76	53.20	71.10	3.29	9.93	17.74	26.14	33.73
Date.....	1931	1930-31	1929-31	1929-32	1929-33	1917	1917-18	1920-31	1917-20	1917-21
Wettest.....	25.93	46.97	64.38	86.33	101.90	14.57	24.12	34.25	43.92	52.22
Date.....	1927	1901-02	1921-23	1901-04	1901-05	1935	1901-02	1901-03	1901-04	1901-05
Treesbank (1885-1937)										
Driest.....	9.88	26.48	45.72	58.56	76.71	4.12	10.80	19.66	28.11	36.67
Date.....	1886	1897-98	1896-98	1886-89	1886-90	1934	1897-98	1916-18	1915-18	1914-18
Brandon (1885-1937)										
Driest.....	7.94	19.88	32.02	45.28	66.22	2.97	8.69	15.72	24.61	32.94
Date.....	1894	1894-95	1893-95	1892-95	1892-96	1897	1893-94	1892-94	1892-95	1893-97
Morden (1886-1937)										
Driest.....	8.74	22.99	36.90	48.52	60.84	2.95	8.70	15.14	20.72	27.94
Date.....	1886	1889-90	1888-90	1886-89	1886-90	1913	1913-14	1913-15	1913-16	1913-17
Russell (1884-1937)										
Driest.....						3.24	10.09	16.62	21.66	29.41
Date.....						1900	1933-34	1898-1900	1897-1900	1930-34

TABLE V

TOTAL PRECIPITATION FROM PRECEDING AUGUST 1st TO JULY 31st

WINNIPEG

Year	Preceding Harvest and Fall Aug. 1-Oct. 31	Preceding Nov. to March Nov. 1-March 31	Crop Season Apr. 1-July 31	Total
1874			10.16	
1875	6.44	3.02	9.22	18.68
1876	7.12	5.66	11.32	24.10
1877	11.44	4.87	15.60	31.91
1878	4.63	6.92	17.20	28.75
1879	6.51	4.58	17.22	28.31
1880	3.92	6.22	12.59	22.73
1881	9.91	6.18	6.36	22.45
1882	5.92	8.75	10.06	24.73
1883	6.31	4.68	7.62	18.61
1884	8.60	5.35	7.85	21.80
1885	12.18	3.73	9.46	25.37
1886	3.32	3.55	4.79	11.66
1887	7.14	3.67	9.11	19.92
1888	3.71	4.59	8.45	16.75
1889	5.32	3.87	5.47	14.66
1890	4.48	4.97	11.37	20.82
1891	9.78	2.93	8.71	21.42
1892	7.15	4.92	9.37	21.44
1893	5.43	5.98	13.82	25.23
1894	3.53	6.75	7.17	17.45
1895	4.74	5.71	9.97	20.42
1896	1.82	4.47	16.93	23.22
1897	4.48	4.94	10.29	19.71
1898	2.67	5.79	9.74	18.20
1899	10.32	5.58	10.01	25.91
1900	6.18	2.59	6.32	15.09
1901	8.82	3.48	15.48	27.78
1902	5.96	4.03	9.79	19.78
1903	4.17	3.98	7.48	15.63
1904	5.46	6.54	12.00	24.00
1905	5.01	4.22	12.57	21.80
1906	4.00	3.62	14.28	21.90
1907	3.05	6.64	7.48	17.17
1908	4.99	4.97	9.63	19.59
1909	6.54	5.35	8.21	20.10
1910	5.87	8.34	6.25	20.46
1911	5.97	4.66	14.18	24.81
1912	6.60	1.96	12.86	21.42
1913	5.28	2.61	6.30	17.19
1914	6.75	3.12	11.00	20.87
1915	6.55	3.67	6.52	16.74
1916	6.05	8.59	9.73	24.37
1917	6.70	4.33	5.65	16.68
1918	4.99	3.12	7.86	15.97
1919	4.89	6.69	11.80	23.38
1920	8.03	6.81	5.97	20.81
1921	5.24	7.04	8.89	21.17
1922	7.02	3.71	10.40	21.13
1923	4.87	7.78	8.30	20.95
1924	2.24	2.11	8.04	12.39
1925	7.71	6.01	4.39	18.11
1926	6.70	2.60	6.53	15.83
1927	10.02	3.22	10.06	23.30
1928	8.56	3.72	12.55	24.83
1929	4.24	4.06	6.29	14.59
1930	3.84	4.69	12.41	20.94
1931	5.28	3.47	6.98	15.73
1932	7.32	5.44	7.17	19.93
1933	5.48	4.82	6.99	17.29
1934	6.99	6.17	7.43	20.59
1935	8.04	6.32	8.97	23.33
1936	7.76	6.22	5.66	19.64
1937	3.55	4.32		

TABLE V (Continued)

TOTAL PRECIPITATION FROM PRECEDING AUGUST 1st TO JULY 31st
MORDEN

Year	Preceding Harvest and Fall Aug. 1-Oct. 31	Preceding Nov. to March Nov. 1-March 31	Crop Season Apr. 1-July 31	Total
1885			9.69	
1886	1.64	2.75	4.35	8.74
1887	3.00	2.80	9.40	15.20
1888	3.60	4.70	5.91	14.21
1889	2.24	1.58	6.55	10.37
1890	2.20	3.35	6.77	12.32
1891	6.82	1.82	10.95	19.59
1892	6.10	6.82	10.26	23.18
1893	5.90	3.30	10.30	19.50
1894	2.59	2.62	6.96	12.17
1895	4.74	2.49	7.92	15.15
1896	4.24	2.87	18.14	25.25
1897	5.52	5.85	11.03	22.40
1898	4.32	1.95	9.40	15.67
1899	6.68	2.25	10.78	19.71
1900	3.85	2.65	3.01	9.51
1901	8.66	3.95	11.41	24.02
1902	5.68	2.75	8.80	17.23
1903	3.85	2.90	5.19	11.94
1904	8.07	6.47	16.20	30.74
1905	6.84	4.13	11.56	22.53
1906	4.21	4.97	17.74	26.92
1907	2.57	8.81	4.97	16.35
1908	3.40	5.62	8.59	17.61
1909	5.00	4.24	11.28	20.52
1910	1.93	5.52	5.15	12.60
1911	4.77	4.90	7.50	17.17
1912	5.11	3.95	8.65	17.71
1913	7.60	4.95	2.95	15.50
1914	5.88	6.05	5.75	17.68
1915	3.88	3.90	6.44	14.22
1916	4.83	12.43	5.58	22.84
1917	4.32	6.15	7.22	17.69
1918	3.51	4.01	8.67	16.19
1919	5.60	5.02	10.53	21.15
1920	4.51	1.60	5.86	11.97
1921	3.26	4.20	10.78	18.24
1922	4.14	3.13	7.94	15.21
1923	5.38	8.01	3.81	17.20
1924	5.77	4.14	7.49	17.40
1925	9.12	5.37	8.33	22.82
1926	7.08	4.79	8.89	20.76
1927	8.41	7.28	12.50	28.19
1928	5.09	4.04	16.44	25.57
1929	2.19	4.24	3.30	9.73
1930	3.95	5.44	8.70	18.09
1931	3.32	4.89	4.28	12.49
1932	6.72	4.65	7.30	18.67
1933	5.15	3.42	8.00	16.57
1934	4.02	5.76	6.11	15.89
1935	3.46	4.50	11.18	19.14
1936	4.87	5.40	3.51	13.78
1937	3.74	3.44	21.18	28.36

TABLE V (Continued)

TOTAL PRECIPITATION FROM PRECEDING AUGUST 1st TO JULY 31st
TREESBANK (ST. ALBAN'S)

Year	Preceding Harvest and Fall Aug. 1-Oct. 31	Preceding Nov. to March Nov. 1-March 31	Crop Season Apr. 1-July 31	Total
1885			10.71	
1886	1.26	2.34	6.28	9.88
1887	3.97	2.04	12.58	18.59
1888	3.31	4.20	10.80	18.31
1889	3.37	2.79	5.62	11.78
1890	5.74	2.50	9.91	18.15
1891	9.18	1.76	11.03	21.97
1892	5.40	3.61	10.09	19.10
1893	3.22	3.63	6.31	13.16
1894	3.00	5.07	8.93	17.00
1895	3.88	3.25	9.62	16.75
1896	2.95	3.87	12.42	19.24
1897	3.24	5.21	4.77	13.22
1898	3.66	3.57	6.03	13.26
1899	6.94	3.43	12.77	23.14
1900	4.13	3.74	4.74	12.61
1901	12.49	3.57	13.61	29.67
1902	4.30	5.78	8.36	18.44
1903	1.88	4.41	8.49	14.78
1904	9.63	5.22	7.90	22.75
1905	3.59	2.57	11.86	18.02
1906	4.93	2.94	6.33	14.20
1907	5.66	4.72	5.53	15.91
1908	7.57	3.50	8.00	19.07
1909	3.66	5.43	8.71	17.80
1910	2.83	4.83	8.21	15.87
1911	3.96	5.48	10.50	19.94
1912	9.50	2.42	11.53	23.45
1913	6.03	4.30	6.29	22.62
1914	5.43	4.38	8.56	18.37
1915	3.55	1.92	8.45	13.92
1916	7.21	6.36	8.54	22.11
1917	5.84	4.78	4.67	15.29
1918	3.90	3.28	6.45	13.63
1919	5.95	4.63	12.14	22.72
1920	6.59	4.21	7.20	18.00
1921	6.93	5.26	7.26	19.45
1922	8.34	4.11	9.32	21.77
1923	6.37	8.64	10.71	25.72
1924	3.76	3.91	9.88	17.55
1925	7.66	5.10	8.97	21.73
1926	7.93	2.97	13.70	24.60
1927	9.60	6.14	11.96	27.70
1928	6.50	4.22	12.74	23.46
1929	2.14	2.83	6.59	11.56
1930	3.94	6.69	10.48	21.11
1931	3.80	2.64	7.71	14.15
1932	7.37	4.57	7.98	19.92
1933	6.38	4.23	10.62	21.23
1934	8.13	5.11	4.12	17.36
1935	3.54	4.98	15.52	24.04
1936	4.28	5.58	4.88	14.74
1937	3.73	4.86	12.56	21.15

TABLE V (Continued)

TOTAL PRECIPITATION FROM PRECEDING AUGUST 1st TO JULY 31st
BRANDON

Year	Preceding Harvest and Fall Aug. 1-Oct. 31	Preceding Nov. to March Nov. 1-March 31	Crop Season Apr. 1-July 31	Total
1884			4.30	
1885	0.90	2.23	9.80	12.93
1886	1.15	2.06	7.63	10.84
1887	3.29	2.69	16.95	22.93
1888	4.94	3.62	5.41	13.97
1889	1.37	2.86	4.32	8.55
1890	3.88	3.71	8.01	15.60
1891	9.10	2.87	10.52	22.49
1892	4.03	2.20	7.03	13.26
1893	4.50	2.84	4.80	12.14
1894	1.05	3.00	3.89	7.94
1895	1.38	1.67	8.89	11.94
1896	3.07	5.48	12.39	20.94
1897	3.40	8.55	2.97	14.92
1898	3.80	5.36	9.63	18.79
1899	7.70	7.53	8.17	23.40
1900	4.35	1.72	4.07	10.14
1901	11.19	1.85	13.27	26.31
1902	5.10	3.36	14.66	23.12
1903	1.05	4.20	7.55	12.80
1904	7.98	9.94	7.40	25.32
1905	3.45	3.02	11.23	17.70
1906	5.71	2.68	10.91	19.30
1907	3.99	8.14	8.76	20.89
1908	7.26	3.00	8.57	18.83
1909	4.59	5.18	9.46	19.23
1910	1.88	5.38	5.69	12.95
1911	2.98	5.90	7.86	16.74
1912	8.87	1.77	11.20	21.84
1913	4.87	3.30	5.43	13.60
1914	4.97	2.34	8.91	16.22
1915	5.03	1.45	8.50	14.98
1916	4.11	6.95	9.47	20.53
1917	6.57	4.00	4.25	14.82
1918	3.24	2.42	6.50	12.16
1919	4.43	3.66	8.84	16.93
1920	4.93	3.60	5.65	14.18
1921	6.65	5.13	9.44	21.22
1922	8.56	3.48	7.17	19.21
1923	6.90	5.28	10.57	22.75
1924	5.94	3.17	11.71	20.82
1925	9.94	4.82	7.97	22.73
1926	7.72	1.45	6.40	15.57
1927	10.11	5.10	13.05	28.26
1928	7.40	3.83	13.06	24.29
1929	2.13	7.75	7.75	17.63
1930	4.52	2.55	13.66	20.73
1931	3.18	3.55	8.84	15.57
1932	4.67	4.05	13.82	22.54
1933	4.71	3.00	6.69	14.40
1934	8.62	2.76	4.85	16.23
1935	4.60	4.10	16.25	24.95
1936	5.94	4.00	5.92	15.86
1937	4.70	3.40	13.85	21.95

TABLE V (Continued)

TOTAL PRECIPITATION FROM PRECEDING AUGUST 1st TO JULY 31st
MINNEDOSA

Year	Preceding Harvest and Fall Aug. 1-Oct. 31	Preceding Nov. to March Nov. 1-March 31	Crop Season Apr. 1-July 31	Total
1883			5.58	
1884	4.20	5.33	7.99	17.52
1885	8.47	3.25	9.79	21.51
1886	2.97	2.72	6.86	12.55
1887	2.80	1.75	12.16	16.71
1888	2.91	3.42	10.00	16.33
1889	2.89	2.63	4.87	10.39
1890	3.31	4.36	9.94	17.61
1891	7.34	3.60	9.07	20.01
1892	3.35	2.01	6.57	11.93
1893	4.15	4.68	5.62	14.45
1894	3.63	5.47	6.66	15.76
1895	3.40	2.72	9.14	15.26
1896	3.37	4.56	12.33	20.26
1897	5.78	6.62	5.54	17.94
1898	3.09	2.94	8.30	14.33
1899	7.84	2.58	8.78	19.20
1900	4.36	3.33	6.13	13.82
1901	9.57	3.75	12.43	25.75
1902	4.72	4.81	11.69	21.22
1903	2.28	3.57	10.13	15.98
1904	7.48	6.23	9.67	23.38
1905	4.05	3.22	8.30	15.57
1906	4.70	2.58	12.29	19.57
1907	3.49	5.99	8.38	17.86
1908	5.02	2.24	9.28	16.54
1909	4.84	4.03	8.08	16.95
1910	2.81	3.09	6.76	12.66
1911	3.39	4.64	8.59	16.62
1912	10.05	2.94	8.59	21.58
1913	5.82	3.22	8.21	17.25
1914	4.12	3.67	8.41	16.20
1915	4.56	2.93	9.00	16.49
1916	4.13	5.29	10.49	19.91
1917	5.96	4.39	3.29	13.64
1918	2.76	3.37	6.64	12.77
1919	3.98	3.80	8.63	16.41
1920	2.82	3.59	7.58	13.99
1921	7.16	3.08	7.59	17.83
1922	8.75	4.25	9.17	22.17
1923	4.93	6.48	12.97	24.38
1924	2.24	2.23	9.61	14.08
1925	7.54	4.55	6.97	19.06
1926	3.90	1.43	5.16	10.49
1927	9.73	5.65	10.55	25.93
1928	6.64	2.65	10.74	20.03
1929	2.81	2.20	4.95	9.96
1930	2.66	4.52	7.77	14.95
1931	3.19	1.64	5.02	9.85
1932	5.13	3.67	9.64	18.44
1933	5.75	3.39	8.76	17.90
1934	7.23	3.68	6.11	17.02
1935	4.49	4.90	14.57	23.96
1936	6.86	4.10	3.79	14.75
1937	4.90	2.79		

TABLE V (Concluded)

TOTAL PRECIPITATION FROM PRECEDING AUGUST 1st TO JULY 31st

RUSSELL

Year	Preceding Harvest and Fall Aug. 1 Oct. 31	Preceding Nov. to March Nov. 1 March 31	Crop Season Apr. 1-July 31	Total
1883			6.03	
1884	4.94	4.01	6.20	15.15
1885	4.54	2.85	14.85	22.24
1886	3.72	3.43	7.36	14.51
1887	3.86	2.51	11.44	17.81
1888	5.53	5.13	11.96	22.62
1889	3.66	2.35	3.95	9.96
1890	1.67	4.38	7.69	13.74
1891	9.33	3.03	7.27	19.63
1892	3.13	2.65	7.28	13.06
1893	3.24		9.97	
1894	3.68	5.11		
1895	4.96			
1896	4.06		11.86	
1897	2.92		5.04	
1898	2.65	7.35	6.13	16.13
1899	7.57	3.34	7.25	18.16
1900	4.93	3.79	3.24	11.96
1901	12.89	4.70	9.75	27.34
1902	5.10	3.40	9.50	18.00
1903	1.84	3.40	6.13	11.37
1904	4.71	4.88	5.23	14.82
1905	3.08	4.35	6.22	13.65
1906	6.74	2.65	9.09	18.48
1912			8.81	
1913	7.26		9.78	
1914	3.79		7.33	
1915	4.36		8.64	
1916	3.39		10.33	
1917	4.37		5.52	
1918	2.34			
1922			8.22	
1923	5.08		10.76	
1924	3.76		6.75	
1925	5.79		7.66	
1926	3.33		6.76	
1927	8.78		7.81	
1928	6.79		8.63	
1929	3.11		6.08	
1930	1.50		8.19	
1931	3.17		4.32	
1932	8.33		8.21	
1933	4.44		6.96	
1934	5.76		4.63	
1935	3.18		11.82	
1936	4.70		6.82	
1937	1.89		5.16	

TABLE VI

FREQUENCY OF RAINY DAYS
WINNIPEG (April to August, incl.)

Year	Total Rainy Days	Successive Days With Measurable Rain					Successive Days Without Measurable Rain											22 or more
		2	3	4	5 or more	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17	18-19	20-21			
1936	58	6	3	0	0	8	1	2	0	0	0	1	0	1	0	0	0	0
1935	75	12	4	0	0	12	2	0	1	1	1	0	0	0	0	0	0	0
1934	77	8	2	1	0	13	1	3	1	1	1	0	0	0	0	0	0	0
1933	58	7	0	3	1	8	3	0	0	0	0	1	1	0	0	0	0	0
1932	56	11	0	0	0	11	4	0	0	0	1	0	1	0	0	0	0	0
1931	57	9	4	1	0	6	1	0	3	3	0	2	0	0	0	0	0	0
1930	58	9	4	1	0	13	3	1	1	1	0	1	0	0	0	0	0	0
1929	52	5	2	1	0	5	4	1	1	1	1	1	0	0	0	0	0	0
1928	67	12	0	0	2	7	0	2	0	0	0	0	1	0	0	0	0	0
1927	72	9	2	0	2	18	1	0	0	0	0	0	0	0	0	0	0	0
1926	59	4	3	1	0	10	0	1	1	1	2	0	0	0	0	0	0	0
1925	71	8	3	3	1	14	2	2	0	0	0	0	1	0	0	0	0	0
1924	61	7	2	1	0	11	2	1	2	1	1	0	0	0	0	0	0	0
1923	59	5	1	0	1	7	3	2	1	1	1	0	0	0	0	0	0	0
1922	68	6	1	2	0	15	6	1	1	0	0	0	0	0	0	0	0	0
1921	69	6	3	2	0	11	1	1	1	1	1	0	0	0	0	0	0	0
1920	53	6	3	1	0	5	6	2	2	2	1	0	0	0	0	0	0	0
1919	46	6	4	0	1	7	2	3	1	1	0	1	0	0	0	0	0	0
1918	78	8	2	0	3	11	5	1	0	0	0	0	0	0	0	0	0	0
1917	57	6	5	0	0	9	8	1	1	0	0	0	1	0	0	0	0	1
1916	63	7	2	2	0	8	2	0	2	2	0	1	0	0	0	0	0	0
1915	64	8	1	2	0	8	3	1	1	0	1	0	0	0	0	0	0	0
1914	61	6	5	0	0	8	6	0	0	2	1	0	0	0	0	0	0	0
1913	78	7	3	1	0	10	1	3	0	1	0	0	0	0	0	0	0	0
1912	70	10	6	3	1	17	2	0	0	0	1	0	0	0	0	0	0	0
1911	70	4	5	4	0	12	3	0	0	0	0	0	0	0	0	0	0	0
1910	54	5	3	0	2	7	5	2	1	1	0	1	0	0	0	0	0	0
1909	67	8	3	0	2	12	9	1	1	1	0	0	0	0	0	0	0	0
1908	52	6	2	4	1	5	5	1	1	1	1	1	0	0	0	0	0	0
1907	71	6	1	1	0	13	5	2	0	0	1	0	0	0	0	0	0	0

TABLE VI (Concluded)

FREQUENCY OF RAINY DAYS
MINNEAPOLIS (April to August, incl.)

Year	Total Rainy Days	Number of Cases of											
		Successive Days With Measurable Rain						Successive Days Without Measurable Rain					
		2	3	4	5 or more	2-3	4-5	6-7	8-9	10-11	12-13	14-15	16-17
1936	45				0	8	2	4	0	1	1	0	1
1935	62	6	3	0	2	15	5	3	0	1	1	0	0
1934	53	6	0	1	0	11	4	3	2	2	0	0	0
1933	55	8	0	1	0	9	5	3	1	1	0	0	0
1932	56	7	2	3	1	8	3	1	1	3	1	0	0
1931	45	8	1	0	0	5	3	3	0	3	0	0	0
1930	58	12	2	2	0	7	5	1	1	1	0	1	0
1929	46	5	1	2	0	5	3	1	1	1	0	1	0
1928	64	6	0	3	1	12	3	0	1	0	1	0	0
1927	67	11	2	1	3	14	7	4	2	1	1	0	0
1926	46	7	1	0	0	7	3	1	0	1	0	0	0
1925	62	6	6	3	1	8	3	0	1	1	0	2	1
1924	54	8	4	2	1	12	5	2	2	0	0	0	0
1923	59	11	4	4	1	14	3	3	2	0	0	0	0
1922	57	11	2	1	0	10	4	2	1	1	1	1	0
1921	54	9	4	1	1	9	3	2	2	2	0	0	0
1920	41	4	4	1	0	6	7	4	1	1	1	0	1
1919	37	5	3	2	0	8	5	0	2	0	0	0	0
1918	58	4	4	3	1	5	3	2	3	0	0	0	0
1917	44	4	1	2	1	12	3	0	1	0	0	0	0
1916	60	8	3	0	2	7	5	4	2	1	2	0	0
1915	58	10	1	1	1	10	3	3	1	1	1	0	0
1914	61	9	1	1	1	10	2	4	1	0	1	0	0
1913	54	8	0	0	3	10	3	3	0	0	0	0	0
1912	78	3	4	4	0	13	5	2	0	0	1	0	1
1911	67	6	7	1	3	5	4	0	0	1	1	0	0
1910	46	7	1	1	2	12	4	3	0	0	0	0	0
1909	54	7	5	2	0	14	4	2	2	0	0	0	0
1908	63	7	4	2	0	14	3	2	2	0	0	0	0
1907	72	4	9	2	1	12	6	1	1	0	0	0	0
1906	60	3	3	4	2	10	4	2	0	2	1	0	0

TABLE VII

CHANCES FOR AND AGAINST PRECIPITATION
WINNIPEG

Month	No precipi- tation		Trace or better		.04 or better		.20 or better		.60 or better		1.00 or better		1.50 or better		2.00 or better	
	For	Against	For	Against	For	Against	For	Against	For	Against	For	Against	For	Against	For	Against
January	18	13	13	18	9	52	1	30	*		*		0	All	0	All
February	33	23	23	33	1	7	1	27	*		0	All	0	All	0	All
March	37	25	25	37	4	17	3	55	*		*	All	0	All	0	All
April	19	11	11	19	9	51	3	57	*		*		*	All	0	All
May	19	12	12	19	6	25	3	28	1	61	*		*	All	0	All
June	31	29	29	31	8	22	7	53	1	29	*		*	All	0	All
July	35	27	27	35	7	24	3	30	1	30	*		*	All	0	All
August	37	25	25	37	6	25	3	28	1	30	0	All	0	All	0	All
September	17	13	13	17	13	47	7	53	1	59	1	All	0	All	0	All
October	37	25	25	37	5	26	2	29	1	61	*	All	0	All	0	All
November	17	13	13	17	1	5	1	19	*		*		0	All	0	All
December	17	14	14	17	9	53	1	30	*		*		0	All	0	All

MINNEDOSA

Month	No precipi- tation		Trace or better		.04 or better		.20 or better		.60 or better		1.00 or better		1.50 or better		2.00 or better	
	For	Against	For	Against	For	Against	For	Against	For	Against	For	Against	For	Against	For	Against
January	21	10	10	21	4	27	1	30	*		0	All	0	All	0	All
February	3	1	1	3	3	25	1	27	*		*	All	0	All	0	All
March	21	10	10	21	4	27	1	30	*		*	All	0	All	0	All
April	2	1	1	2	1	5	1	14	1	59	*		*	All	0	All
May	43	19	19	43	6	25	5	57	1	29	1	59	*	All	0	All
June	8	7	7	8	3	7	2	13	1	30	1	92	*	All	0	All
July	37	25	25	37	8	23	7	55	1	30	1	61	*	All	0	All
August	39	23	23	39	7	24	7	11	1	29	1	89	*	All	0	All
September	2	1	1	2	1	4	1	59	1	61	1		*	All	0	All
October	45	17	17	45	9	53	3	59	1	89	*		*	All	0	All
November	7	3	3	7	7	53	1	29	1	61	*	All	0	All	0	All
December	22	9	9	22	7	55	1	30	0	All	0	All	0	All	0	All

*Negligible Chance

TABLE VIII

APRIL
FREQUENCY OF RAINY DAYS ACCORDING TO WIND-DIRECTION
 Average Frequency per Month

Amount in Inches On One Day	No Rain	T to .04	.04 to .20	.20 to .60	.60 to 1.00	1.00 to 1.50	1.50 to 2.00	Over 2.00
North								
Winnipeg.....	4.5	1.0	0.2	0.3	*	0	0	0
Minnedosa.....	1.8	0.3	0.1	*	*	0	0	0
The Pas.....	2.3	0.3	0.5	0.1	0	0	0	0
Qu'Appelle.....	1.0	0.6	0.2	0.1	0	0	0	0
Prince Albert.....	2.7	0.9	0.3	0.3	*	0	0	0
Northeast								
Winnipeg.....	2.5	0.6	0.4	0.2	*	0	0	0
Minnedosa.....	1.6	0.7	0.4	0.4	0.1	0.1	0	0
The Pas.....	3.9	0.9	0.8	0.5	0	0	0	0
Qu'Appelle.....	2.3	0.6	0.6	0.5	*	0	0	0
Prince Albert.....	1.5	0.3	0.5	0.4	0.3	0	0	0
East								
Winnipeg.....	1.0	0.4	0.4	0.2	0.1	0	0	0
Minnedosa.....	1.1	0.3	0.4	0.3	0	0	0	0
The Pas.....	1.7	0.2	0.2	0.1	0	0	0	0
Qu'Appelle.....	1.2	0.5	0.6	0.2	*	0	0	0
Prince Albert.....	2.3	1.1	0.6	0.3	0	0	0	0
Southeast								
Winnipeg.....	3.2	1.4	0.9	0.3	0	*	0	0
Minnedosa.....	3.5	1.1	0.1	0.5	0.1	0	0	0
The Pas.....	4.7	0.8	0.5	0.3	*	0	0	0
Qu'Appelle.....	3.3	0.8	1.0	0.4	*	0	0	0
Prince Albert.....	2.0	0.4	0.1	0.1	0	0	0	0
South								
Winnipeg.....	1.2	0.4	0.3	0.1	0	0	0	0
Minnedosa.....	0.3	0	0.1	0	0	0	0	0
The Pas.....	0.9	0.1	0.2	0	0	0	0	0
Qu'Appelle.....	2.3	0.3	0.6	*	0	0	0	0
Prince Albert.....	2.8	0.1	0.2	0	0	0	0	0
Southwest								
Winnipeg.....	1.6	0.6	0.1	*	0	0	0	0
Minnedosa.....	0.7	0.2	0.3	0	0	0	0	0
The Pas.....	1.7	0.3	*	0.1	0	0	0	0
Qu'Appelle.....	2.1	0.7	0.1	0	0	0	0	0
Prince Albert.....	1.1	0.2	0	0	0	0	0	0
West								
Winnipeg.....	0.8	0.2	0	0.1	0	0	0	0
Minnedosa.....	0.7	0.1	0.1	0	0	0	0	0
The Pas.....	1.4	0.1	0.1	0	0	0	0	0
Qu'Appelle.....	1.6	0.4	0.1	0	0	0	0	0
Prince Albert.....	2.7	0.5	0.2	*	0	0	0	0
Northwest								
Winnipeg.....	3.2	1.8	0.5	0.2	*	0	0	0
Minnedosa.....	5.1	1.4	0.4	0.4	0.1	0	0	0
The Pas.....	3.7	0.3	0.4	*	0	0	0	0
Qu'Appelle.....	4.4	1.7	0.7	0.2	0.1	*	0	0
Prince Albert.....	2.1	0.9	0.3	0.3	0	0	0	0
Calm								
Winnipeg.....	0.7	0.2	*	*	0	0	0	0
Minnedosa.....	4.7	1.4	0.6	0.4	0	0	0	0.1
The Pas.....	2.7	0.2	0.1	0	*	0	0	0
Qu'Appelle.....	1.0	0.3	0.1	0.1	0	0	0	0
Prince Albert.....	3.1	0.9	0.5	0	0	0	0	0

*Less than 0.1

TABLE VIII (Continued)

MAY
FREQUENCY OF RAINY DAYS ACCORDING TO WIND-DIRECTION
Average Frequency per Month

Amount in Inches On One Day	No Rain	T to .04	.04 to .20	.20 to .60	.60 to 1.00	1.00 to 1.50	1.50 to 2.00	Over 2.00
North								
Winnipeg	4.8	0.8	0.3	0.2	*	0	*	0
Minnedosa	1.6	0.2	0	0	0.1	0	0	0
The Pas...	1.4	0.3	0.1	*	*	0	0	0
Qu'Appelle...	1.8	0.7	0.2	0.2	0	*	0	0
Prince Albert	3.5	0.7	0.5	0.5	*	0	0	0
Northeast								
Winnipeg	2.4	0.6	0.5	0.4	0.1	0	0.1	0
Minnedosa	2.6	0.3	0.3	0.3	0	0.3	0	0
The Pas...	3.8	1.2	0.3	0.5	0.1	0	0	0
Qu'Appelle...	2.1	0.4	0.3	0.4	0.1	0.2	*	0
Prince Albert	1.6	0.9	0.6	0.3	0.1	0.1	0	0
East								
Winnipeg	1.0	0.4	0.5	0.4	*	0	0	0
Minnedosa	2.8	0.1	0.2	0.3	0	0	0	0
The Pas...	2.3	0.5	0.3	0.1	0	0	0	0
Qu'Appelle...	1.0	0.5	0.6	0.2	0	0	0	0
Prince Albert	2.6	0.3	0.5	0.3	0	0	0	0
Southeast								
Winnipeg	3.6	0.9	0.4	0.5	0.2	0.1	*	0
Minnedosa	3.9	0.9	0.4	0.2	0.2	0	0	0
The Pas...	5.7	0.9	0.7	0.5	0	0	0	0
Qu'Appelle	4.2	0.9	1.1	0.2	0.1	*	0	0
Prince Albert	3.0	0.8	0.4	0.5	0	0	0	0
South								
Winnipeg	1.6	0.6	0.4	0.2	0	*	0	0
Minnedosa	0.7	0.1	0.1	0.1	0	0	0	0
The Pas	0.8	0.2	0.1	*	0	0	0	0
Qu'Appelle	1.7	0.8	0.2	0	0	0	0	0
Prince Albert	1.9	0.5	0.1	0.2	0	0	0	0
Southwest								
Winnipeg	1.6	0.5	0.2	*	0	0	0	0
Minnedosa	0.9	0.1	0.1	0	0	0	0	0
The Pas	1.5	0.3	0.1	0	0	0	0	0
Qu'Appelle	3.1	0.6	0.3	0.2	*	0	0	0
Prince Albert	1.1	0.1	0.2	*	0	0	0	0
West								
Winnipeg	0.5	0.3	0.1	0.1	0	0	0	0
Minnedosa	0.9	0.3	0.1	0	0	0	0	0
The Pas...	1.1	0.1	*	0.1	0	0	0	0
Qu'Appelle	0.6	0.5	0.2	0	0	0	0	0
Prince Albert	1.6	0.4	0.4	*	0	0	0	0
Northwest								
Winnipeg	4.0	1.2	0.3	0.2	0.2	0	0	0
Minnedosa	4.9	1.2	0.7	0.3	0	0.1	0	0
The Pas...	4.5	0.7	0.3	0.3	0	0	*	0
Qu'Appelle	4.0	1.3	0.6	0.2	*	0	0	0
Prince Albert	1.7	0.7	0.1	0	0	0	0	0
Calm								
Winnipeg	0.5	*	0.1	*	0	0	0	0
Minnedosa	3.5	1.0	0.8	0.5	0.1	0	0	0
The Pas	2.3	0.1	0.2	0.3	0	0	0	0
Qu'Appelle	0.8	0.2	0.1	0.2	0	0	0	0
Prince Albert	2.8	0.9	0.3	0.1	*	0	0	0

*Less than 0.1

TABLE VIII (Continued)

JUNE
FREQUENCY OF RAINY DAYS ACCORDING TO WIND-DIRECTION
Average Frequency per Month

Amount in Inches On One Day	No Rain	T to .04	.04 to .20	.20 to .60	.60 to 1.00	1.00 to 1.50	1.50 to 2.00	Over 2.00
North								
Winnipeg....	2.8	0.6	0.4	0.2	0.1	0.1	0	0
Minnedosa	0.8	0.1	0.4	0.2	0	0	0	0
The Pas	2.4	0.4	0.3	0.3	0	0	0	0
Qu'Appelle	0.6	0.1	0.1	0.2	0	0	0	0
Prince Albert	1.8	1.3	0.8	0.3	0.1	0.1	0	0
Northeast								
Winnipeg	1.5	0.6	0.5	0.2	0.1	0.1	*	0
Minnedosa	1.5	0.5	0.8	0.3	0.4	0.2	0	0
The Pas	3.0	0.4	0.7	0.5	0.2	0.1	0	0
Qu'Appelle	0.8	0.6	0.7	0.6	0.1	0.1	*	*
Prince Albert	1.2	0.6	0.3	0.6	0.1	0.1	*	0
East								
Winnipeg.....	1.2	0.4	0.2	0.3	0.1	0	0	0
Minnedosa.....	0.8	0.4	0.4	0.3	0.1	0.1	0	0
The Pas	1.0	0.3	0.3	0.3	0	*	0	0
Qu'Appelle.....	0.8	0.5	0.2	0.3	*	0.2	0	0
Prince Albert	1.2	0.8	0.4	0.5	0.3	0	0	0
Southeast								
Winnipeg	2.5	1.2	0.8	1.1	0.1	0	0.1	0
Minnedosa	2.6	0.9	0.2	0.5	0.1	0	0.2	0
The Pas	2.5	0.9	0.7	0.5	0.2	*	0	0
Qu'Appelle	2.7	0.9	1.1	0.6	0.2	0.2	*	0
Prince Albert	1.7	0.7	0.5	0.3	*	*	0	0
South								
Winnipeg.....	1.6	0.7	0.3	0.2	0.2	0	0	0
Minnedosa	0.7	0.3	0.2	0	0	0	0	0
The Pas	1.3	*	0.2	0.1	0	0	0	0
Qu'Appelle	1.5	0.2	0.5	0.2	0	0	0	0
Prince Albert	1.3	0.4	0.1	0.1	0	*	0	0
Southwest								
Winnipeg	1.5	0.8	0.7	0.1	*	0	0	0
Minnedosa	0.9	0.2	0.3	0	0	0	0	0
The Pas	1.5	0.3	0.5	*	0	0	0	0
Qu'Appelle	2.6	0.9	0.7	0.2	0	0	0	*
Prince Albert	1.0	0.3	0.3	0.3	0	0	0	0
West								
Winnipeg.....	1.3	0.6	0.3	0.1	0	0	0	0
Minnedosa	1.3	0.2	0.4	0.2	0	0	0	0
The Pas	1.0	0.3	0.2	*	*	0	0	0
Qu'Appelle	1.4	0.3	0.2	0.3	*	0	0	0
Prince Albert	1.7	0.4	0.5	0.1	0	*	0	0
Northwest								
Winnipeg.....	3.1	1.2	0.7	0.4	0.1	0	0	0
Minnedosa	3.8	1.1	0.4	0.7	0.2	0.1	0	0
The Pas	3.5	1.0	0.5	0.2	0.1	*	0	0
Qu'Appelle	4.4	1.4	1.3	0.6	0.1	0	0	0
Prince Albert	2.1	0.6	0.4	0.2	*	0	0	0
Calm								
Winnipeg.....	0.6	0.3	0	0	0	0	0	0
Minnedosa	3.8	0.8	1.8	0.5	0.2	0	0.1	0
The Pas	2.3	0.5	0.3	0.4	0.2	0	0	0
Qu'Appelle	0.8	0.2	0.2	0.2	*	0	0	0
Prince Albert	2.7	1.5	0.9	0.7	0.1	0.1	0	0

*Less than 0.1

TABLE VIII (Concluded)

JULY
FREQUENCY OF RAINY DAYS ACCORDING TO WIND-DIRECTION
Average Frequency per Month

Amount in Inches On One Day	No Rain	T to .04	.04 to .20	.20 to .60	.60 to 1.00	1.00 to 1.50	1.50 to 2.00	Over 2.00
North								
Winnipeg.....	2 0	0.6	0.1	0.1	*	*	0	0
Minnedosa.....	0.5	0.1	0.2	0.1	0	0	0	0
The Pas.....	1 8	0.3	0.5	0.3	*	*	0	0
Qu'Appelle.....	1.1	0.2	0.1	0.1	0	0	0	0
Prince Albert.....	1 4	0.7	0.5	0.1	0.1	*	0	0
Northeast								
Winnipeg.....	1.6	0.4	0.2	0.3	0.2	0.1	*	0
Minnedosa.....	0.7	0.5	0.5	0.2	0	0	0	0
The Pas.....	2.1	0.6	0.5	0.5	*	0	0	0
Qu'Appelle.....	0.6	0.2	0.2	0.1	*	*	0	0
Prince Albert.....	0.6	0.3	0.2	0	0.1	0	*	0
East								
Winnipeg.....	0.5	0.2	0.4	0.3	*	0	0	*
Minnedosa.....	1.1	0.3	0.3	0.3	0	0.2	0	0
The Pas.....	0.9	0.3	0.3	0.2	0.1	*	0	0
Qu'Appelle.....	0.8	0.2	0.2	0.4	0	0	0	0
Prince Albert.....	1 7	0.9	0.5	*	0.1	0.1	0	0
Southeast								
Winnipeg.....	2.6	1.6	1.3	0.7	0.4	0.1	*	0
Minnedosa.....	2.8	0.4	0.2	0.4	0.1	0	0	0.1
The Pas.....	2.2	0.6	0.5	0.5	0.1	0	*	0
Qu'Appelle.....	3 6	1.1	0.8	0.4	0.2	0.3	*	*
Prince Albert.....	2 0	0.6	0.7	0.1	0	0	0	0
South								
Winnipeg.....	2.1	0.4	0.5	0.2	*	0	0	0
Minnedosa.....	1.1	0	0.1	*	0.1	0	0	0
The Pas.....	0.8	0.2	0.1	*	*	0	0	0
Qu'Appelle.....	1 7	0.5	0.3	0.2	0	0	0	0
Prince Albert.....	1 0	0.3	*	*	0	*	0	0
Southwest								
Winnipeg.....	1.2	0.9	0.2	0.2	0	*	0	0
Minnedosa.....	0.5	0.2	0	0.1	0.1	0	0	0
The Pas.....	2.5	0.3	0.3	0.3	0	0	0	0
Qu'Appelle.....	2 8	0.5	0.3	0.1	0.1	0	0	0
Prince Albert.....	1 0	0.3	*	0.1	0.1	0	0	0
West								
Winnipeg.....	1.5	0.8	0.6	0.2	0	0	0	0
Minnedosa.....	0.8	0.2	0	0	0	0	0	0
The Pas.....	2 4	0.2	0.5	0.1	*	0	0	0
Qu'Appelle.....	2.2	0.6	0.3	0.1	*	*	0	0
Prince Albert.....	2 3	0.9	0.7	0.2	0	0	0	0
Northwest								
Winnipeg.....	4 9	1 0	0.6	0.2	0.2	0	0	0
Minnedosa.....	1 5	1 2	0.8	0.2	0.1	0	0	0
The Pas.....	3 7	1 0	0.5	0.3	*	0	0	0
Qu'Appelle.....	5 3	1 4	1 0	0.3	0.1	0	0	0
Prince Albert.....	3 7	0 9	0 7	*	0	0	0	0
Calm								
Winnipeg.....	0 9	0 1	0 2	0	0	0	0	0
Minnedosa.....	8 0	1 4	1 6	1 0	0.3	0	0	0
The Pas.....	3 1	0 9	0 6	0 2	0 1	0	0	0
Qu'Appelle.....	1 4	0 3	0 2	0 2	*	0	0	0
Prince Albert.....	4 0	1 8	0 8	0 7	0 1	0	0	*

*Less than 0.1

TABLE IX

WINNIPEG—SPECIFIC HUMIDITY—JUNE

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	10h.	7h.	10h.	7h.	10h.	7h.	10h.	7h.	10h.	7h.	10h.	7h.	10h.	10h.
1937															
Mean.....	54.1	71.0	51.7	50.6	2.4	11.4	86	52	9.7	17.7	8.3	9.2	62.0	50	52
Max. 23rd.....	66.4	88.0	63.8	79.0	2.6	9.0	87	68	15.2	31.8	13.2	21.5	62.0	62	76
Min. 6th.....	48.8	42.6	48.4	39.6	0.4	3.0	98	78	7.8	6.1	7.6	4.8	36.4	48	37
1936															
Mean.....	54.5	67.6	50.9	58.1	3.6	9.5	79	58	9.8	15.8	7.7	9.2	66.6	48	52
Max. 24th.....	64.6	84.2	59.0	71.0	5.6	13.2	73	54	14.3	28.2	10.1	15.8	66.6	55	66
Min. 1st.....	47.2	51.0	44.0	44.2	3.2	6.8	79	59	7.4	8.5	5.8	5.0	32.6	41	37
1935															
Mean.....	52.8	63.5	49.4	55.7	3.4	7.8	80	62	9.1	13.8	7.3	8.6	66.4	17	50
Max. 30th.....	69.2	82.2	64.8	73.2	4.4	9.0	79	66	16.7	26.3	13.2	17.3	66.4	62	69
Min. 5th.....	37.4	50.6	36.0	42.6	1.4	8.0	89	53	5.0	8.4	4.4	4.5	31.0	35	34
1934															
Mean.....	54.9	67.9	51.9	58.4	3.0	9.5	82	58	10.0	16.0	8.2	9.3	61.0	53	53
Max. 26th.....	59.4	77.2	57.4	68.4	2.0	8.8	89	65	11.9	22.0	10.6	14.1	61.0	56	65
Min. 7th.....	50.4	53.4	45.1	46.4	5.2	7.0	67	60	8.4	9.4	5.6	5.6	46.0	40	40
1933															
Mean.....	61.6	74.7	57.0	63.2	4.6	11.5	77	54	12.8	20.1	9.9	10.9	68.4	54	57
Max. 18th.....	75.2	95.2	61.4	77.6	13.8	17.6	46	44	20.4	40.3	9.4	17.7	68.4	54	72
Min. 12th.....	46.2	67.4	43.2	54.0	3.0	13.4	80	42	7.1	15.7	5.7	6.6	54.0	40	44
1932															
Mean.....	63.1	73.7	58.6	61.7	4.5	9.0	77	63	13.5	19.5	10.4	12.6	65.0	56	60
Max. 6th.....	70.8	86.8	68.0	74.6	2.8	12.2	87	58	17.6	30.6	15.3	17.8	65.0	67	69
Min. 22nd.....	50.0	62.4	48.0	55.2	2.0	7.2	87	65	8.2	13.2	7.1	8.6	46.0	45	50
1931															
Mean.....	59.2	72.4	55.2	61.9	4.0	10.5	78	57	11.8	18.6	9.2	10.6	76.0	52	56
Max. 28th.....	76.6	92.2	73.5	80.8	3.1	11.4	87	62	21.5	36.7	18.2	22.8	76.0	72	77
Min. 6th.....	51.2	56.0	47.6	47.0	3.6	9.0	77	52	8.6	10.5	6.7	5.5	33.9	44	38
1930															
Mean.....	57.8	69.9	54.1	60.6	3.7	9.3	82	59	11.2	17.0	8.2	10.0	61.0	51	54
Max. 28th.....	60.0	68.0	55.0	61.8	5.0	3.2	73	84	12.2	16.0	8.9	13.4	61.0	51	63
Min. 3rd.....	47.8	54.6	45.0	48.5	2.8	6.1	81	65	7.5	9.9	6.1	6.4	43.0	42	42
1929															
Mean.....	55.4	69.4	52.0	60.3	3.4	9.1	80	59	10.2	16.8	8.2	9.9	57.0	50	56
Max. 17th.....	76.0	82.8	72.2	74.8	3.8	8.0	84	69	21.0	26.8	17.7	18.5	57.0	70	72
Min. 1st.....	46.8	64.0	43.8	52.0	3.0	12.0	79	43	7.2	14.0	5.7	6.0	41.0	41	41
1928															
Mean.....	54.5	64.9	52.0	57.6	2.5	7.3	85	65	9.8	14.4	8.3	9.4	59.0	50	52
Max. 15th.....	53.8	68.0	49.6	64.5	4.2	3.5	76	83	9.6	16.0	7.3	13.3	59.0	46	63
Min. 8th.....	52.2	56.0	49.0	49.0	3.2	7.0	80	61	8.9	10.5	7.1	6.4	39.2	46	43

TABLE IX (Continued)

MINNECOTA—SPECIFIC HUMIDITY—JUNE

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.		Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.
1937																
Mean.....	53.0	68.1	50.3	59.0	2.7	9.1	84	60	9.2	16.0	7.7	9.6	54.8	53	49	53
Max. 23rd.....	69.9	81.6	67.7	77.6	2.2	4.0	90	84	17.0	25.7	15.3	21.6	67	77	67	77
Min. 6th.....	42.7	39.6	41.8	37.8	0.9	1.8	93	86	6.1	5.4	5.7	4.6	36.0	36	41	36
1936																
Mean.....	53.4	65.2	49.6	55.8	3.8	9.4	78	57	9.4	14.6	7.3	8.3	62.0	49	47	49
Max. 24th.....	67.2	79.6	60.7	69.7	6.5	9.9	70	62	15.6	23.9	10.9	14.8	57	65	57	65
Min. 1st.....	43.8	49.7	41.7	41.7	2.1	8.0	85	52	6.4	8.1	5.4	4.2	34.8	33	40	33
1935																
Mean.....	52.0	60.0	49.2	53.4	2.8	6.6	83	66	8.8	12.2	7.3	8.1	60.5	49	47	49
Max. 30th.....	62.7	77.2	61.9	71.5	0.8	5.7	96	76	13.3	22.0	12.8	16.7	60.5	60	61	60
Min. 4th.....	36.0	48.0	34.3	39.7	1.7	8.3	85	48	4.7	7.6	4.0	3.7	30.9	29	32	29
1934																
Mean.....	53.3	65.2	50.5	56.6	2.8	8.6	83	60	9.3	14.6	7.7	8.8	60.0	51	49	51
Max. 26th.....	54.9	75.9	53.7	72.7	1.2	3.2	93	86	10.0	20.9	9.3	18.0	60.0	71	53	71
Min. 15th.....	48.6	57.5	46.7	48.3	1.9	9.2	88	52	7.8	11.1	6.9	5.8	50.0	40	45	40
1933																
Mean.....	59.1	72.4	55.9	63.5	3.2	8.9	83	62	11.7	18.6	9.7	11.5	61.0	59	54	59
Max. 18th.....	75.7	86.5	67.4	77.7	8.3	8.8	66	68	20.8	30.3	13.7	20.6	61.0	75	64	75
Min. 10th.....	62.2	66.7	54.7	51.5	7.5	15.2	63	35	13.1	15.3	8.2	5.4	40.3	38	49	38
1932																
Mean.....	59.4	69.0	57.4	63.6	2.0	5.4	89	75	11.9	16.6	10.6	12.4	57.0	61	50	61
Max. 6th.....	67.6	77.1	66.7	69.7	0.9	7.4	96	69	15.8	21.9	15.2	15.1	57.0	66	67	66
Min. 30th.....	57.7	53.7	54.9	51.7	2.6	2.0	85	88	11.2	9.5	9.5	8.4	39.6	51	53	51
1931																
Mean.....	56.0	71.6	52.3	60.4	3.7	11.2	79	53	10.5	18.1	8.3	9.6	68.2	54	50	54
Max. 28th.....	70.7	98.6	67.7	77.7	3.0	20.9	86	40	17.5	45.1	15.1	18.4	68.2	70	67	70
Min. 6th.....	45.0	57.4	44.5	48.7	0.5	8.7	97	54	6.7	11.0	6.5	5.9	27.4	41	44	41
1930																
Mean.....	55.1	67.1	52.6	59.4	2.5	7.7	85	64	10.0	15.5	8.5	9.9	50.5	55	51	55
Max. 21st.....	61.7	70.3	57.7	66.7	4.0	3.6	79	84	12.9	17.3	10.2	14.5	50.5	65	55	65
Min. 3rd.....	41.0	49.3	39.8	44.9	1.2	4.4	91	72	5.7	8.0	5.2	5.8	38.0	41	39	41
1929																
Mean.....	50.9	66.7	48.5	58.2	2.4	8.5	85	61	8.5	15.3	7.2	9.3	68.0	53	46	53
Max. 16th.....	66.4	84.7	62.6	75.9	3.8	8.8	82	68	15.2	28.6	12.5	19.5	68.0	61	73	61
Min. 11th.....	38.4	52.1	37.3	45.7	1.1	6.4	91	63	5.2	8.8	4.7	5.5	25.8	39	36	39
1928																
Mean.....	51.3	61.4	49.4	57.0	1.9	4.4	89	77	8.6	12.8	7.7	9.9	58.4	55	47	55
Max. 29th.....	60.7	74.9	59.7	70.0	1.0	4.9	95	79	12.5	20.2	11.9	16.0	58.4	68	59	68
Min. 1st.....	45.8	53.7	44.2	46.8	1.6	0.9	89	60	6.9	9.5	6.1	5.7	30.0	41	43	41
1923																
Mean.....	56.0	68.6	55.9	61.8	0.1	6.8	99	69	10.5	16.4	10.4	11.3	60.0	58	56	58
Max. 22nd.....	60.7	78.7	59.7	72.0	1.0	6.7	95	73	12.5	23.2	11.9	16.9	60.0	69	59	69
Min. 27th.....	49.7	54.0	48.7	47.7	1.0	6.3	94	64	8.1	9.7	7.6	6.2	37.5	42	48	42

TABLE IX (Continued)

THE PAS—SPECIFIC HUMIDITY—JUNE

	t_d		t_a		$t_d - t_p$		R.H.		W.		W		Min. Temp. Next 7h.		Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.
1937																
Mean.....	53.1	69.4	50.5	60.4	2.6	9.0	85	59	8.6	15.6	7.3	9.2	49.6	49.6	48	54
Max. 30th.....	58.0	88.0	57.0	74.0	1.0	14.0	94	52	10.5	29.5	9.9	15.3	49.0	49.0	56	68
Min. 5th.....	45.0	56.0	42.0	45.0	3.0	11.0	79	40	6.4	9.6	5.1	3.8	41.0	41.0	39	32
1936																
Mean.....	49.5	63.5	48.1	57.0	1.4	6.5	90	67	7.6	12.6	6.8	8.4	45.8	45.8	46	52
Max. 26th.....	50.0	78.0	49.0	70.0	1.0	8.0	93	67	7.7	20.9	7.2	14.0	50.0	50.0	48	66
Min. 1st.....	40.0	44.0	37.0	41.0	3.0	3.0	76	78	5.3	6.1	4.0	4.8	39.0	39.0	33	38
1935																
Mean.....	48.5	63.0	46.8	54.7	1.7	8.3	89	59	7.4	12.3	6.6	7.3	45.3	45.3	45	48
Max. 30th.....	58.0	64.0	58.0	64.0	0.0	0.0	100	100	10.4	12.8	10.4	12.8	58.0	58.0	58	64
Min. 4th.....	36.0	50.0	33.0	41.0	3.0	9.0	73	44	4.5	7.7	3.3	3.4	33.0	33.0	29	29
1934																
Mean.....	52.4	63.2	50.6	56.7	1.8	6.5	90	67	8.5	12.4	7.7	8.3	49.3	49.3	49	52
Max. 27th.....	62.0	71.0	62.0	67.0	0.0	4.0	100	82	12.0	16.0	12.0	13.1	58.0	58.0	62	65
Min. 5th.....	50.0	54.0	47.0	44.0	3.0	10.0	81	43	7.7	8.8	6.2	3.8	37.0	37.0	44	32
1933																
Mean.....	57.5	69.9	55.0	63.2	2.5	6.7	85	69	10.2	15.9	8.7	11.0	50.5	50.5	53	61
Max. 17th.....	74.0	89.0	71.0	79.0	3.0	10.0	86	64	18.4	30.4	15.8	10.5	66.0	66.0	70	75
Min. 11th.....	45.0	58.0	41.0	49.0	4.0	9.0	71	52	6.4	10.4	4.6	5.4	38.0	38.0	36	40
1932																
Mean.....	58.2	68.1	54.6	61.6	3.6	6.5	80	69	10.5	14.8	8.4	10.2	53.6	53.6	52	58
Max. 12th.....	58.0	79.0	58.0	79.0	0.0	0.0	100	100	10.4	21.5	10.4	21.5	57.0	57.0	58	79
Min. 22nd.....	52.0	65.0	52.0	54.0	0.0	11.0	100	48	8.3	13.2	8.3	6.3	46.0	46.0	52	45
1931																
Mean.....	54.1	64.6	50.6	57.0	3.5	7.6	79	72	9.0	13.0	7.1	8.3	48.4	48.4	48	52
Max. 28th.....	72.0	80.0	65.0	73.0	7.0	7.0	69	72	17.0	22.4	11.7	16.1	62.0	62.0	61	70
Min. 9th.....	47.0	59.0	42.0	48.0	5.0	11.0	66	43	6.9	10.9	4.6	4.7	37.0	37.0	36	37
1930																
Mean.....	56.6	67.2	54.5	62.7	2.1	4.5	88	78	9.8	14.3	8.6	11.2	50.4	50.4	53	60
Max. 8th.....	60.0	84.0	64.0	82.0	2.0	2.0	90	92	13.8	25.7	12.4	23.6	59.0	59.0	63	81
Min. 2nd.....	44.0	37.0	43.0	36.0	1.0	1.0	93	91	6.1	4.6	5.7	4.2	37.0	37.0	42	35
1929																
Mean.....	52.7	65.8	50.7	61.3	2.0	4.5	88	78	8.4	13.6	7.4	10.6	45.5	45.5	49	59
Max. 8th.....	58.0	80.0	56.0	79.0	2.0	1.0	89	96	10.3	22.6	9.2	21.7	48.0	48.0	56	79
Min. 22nd.....	43.0	52.0	42.0	48.0	1.0	4.0	92	75	6.0	8.3	5.5	6.2	43.0	43.0	41	44
1928																
Mean.....	51.7	63.2	48.9	58.2	2.8	5.0	82	74	8.2	12.5	6.7	9.2	43.9	43.9	46	55
Max. 26th.....	58.0	78.0	53.0	70.0	5.0	8.0	72	67	10.4	21.0	7.5	14.0	49.0	49.0	49	66
Min. 2nd.....	41.0	60.0	38.0	52.0	3.0	8.0	77	58	5.5	11.1	4.2	6.4	36.0	36.0	34	45

Note—Temperatures read to nearest degree only at The Pas.

TABLE IX (Continued)

QU'APPELLE—SPECIFIC HUMIDITY—JUNE

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	
1937															
Mean.....	52.4	73.6	47.5	57.4	4.9	16.2	67	38	9.0	19.2	6.2	7.3	53	47	
Max. 17th.....	65.0	85.0	64.5	84.0	0.5	1.0	98	95	13.8	13.7	13.5	13.0	64	64	
Min. 14th.....	47.8	81.0	44.0	56.0	3.8	2.5	76	19	7.7	24.8	5.8	4.7	42	34	
1936															
Mean.....	52.3	66.5	49.0	56.5	3.3	10.0	80	54	9.0	15.1	7.2	8.2	47	50	
Max. 26th.....	63.0	83.8	62.0	69.4	1.0	14.4	95	49	13.3	27.6	12.6	13.5	61	63	
Min. 1st.....	53.0	56.6	46.2	43.0	6.8	13.6	61	31	9.2	10.5	5.6	4.2	39	27	
1935															
Mean.....	49.7	60.6	47.7	53.5	2.0	7.1	87	64	8.2	12.3	7.1	7.9	46	49	
Max. 14th.....	51.2	59.0	51.0	57.2	0.2	1.8	99	90	8.7	11.6	8.6	10.4	51	56	
Min. 4th.....	34.8	56.0	33.0	43.8	1.8	12.2	84	36	4.5	10.5	3.8	3.6	31	31	
1934															
Mean.....	50.4	63.7	47.4	54.5	3.0	9.2	81	56	8.3	13.8	6.8	7.7	44	48	
Max. 31st.....	53.0	63.4	52.0	61.8	1.0	1.6	94	92	9.2	13.7	8.7	12.6	51	61	
Min. 23rd.....	48.0	67.4	44.0	51.2	4.0	16.0	74	32	7.6	15.7	5.6	5.0	48	37	
1933															
Mean.....	56.9	72.2	53.8	60.8	3.1	11.4	81	53	10.8	7.3	8.7	3.9	51	54	
Max. 15th.....	63.0	90.0	60.0	74.0	3.0	16.0	85	48	13.5	34.6	11.5	16.6	58	68	
Min. 10th.....	52.0	63.0	49.0	49.0	3.0	14.0	82	36	8.8	13.5	7.2	4.9	47	36	
1932															
Mean.....	56.0	68.6	53.7	60.7	2.3	7.9	86	64	10.5	16.4	9.0	10.5	52	50	
Max. 23rd.....	58.0	68.0	54.0	67.0	4.0	1.0	78	95	11.3	16.0	8.8	15.2	51	67	
Min. 19th.....	55.0	68.0	51.0	54.0	4.0	14.0	77	40	10.0	16.0	7.7	6.4	48	43	
1931															
Mean.....	56.3	72.5	45.0	58.7	11.3	13.8	41	45	10.6	18.6	4.3	8.4	33	50	
Max. 2nd.....	60.0	70.0	54.0	62.0	6.0	8.0	69	65	12.2	17.1	8.4	11.1	50	58	
Min. 24th.....	56.0	72.0	51.0	52.0	5.0	20.0	72	24	10.5	18.3	7.5	4.4	47	33	
1930															
Mean.....	52.4	65.7	50.4	59.0	2.0	6.7	88	68	9.0	14.8	7.8	10.1	49	56	
Max. 7th.....	55.0	75.0	50.0	70.0	5.0	5.0	72	79	10.0	20.3	7.2	16.1	46	68	
Min. 3rd.....	40.0	48.0	38.0	44.0	2.0	4.0	84	74	5.5	7.6	4.6	5.6	36	40	
1929															
Mean.....	51.5	66.3	48.9	60.4	2.6	5.9	84	72	8.7	15.1	7.3	10.9	48	58	
Max. 16th.....	68.0	84.0	62.0	84.0	6.0	0.0	72	100	16.0	28.0	11.5	28.0	59	84	
Min. 22nd.....	43.0	55.0	40.0	46.0	3.0	9.0	78	51	6.2	10.0	4.8	5.1	37	39	
1928															
Mean.....	50.5	61.2	50.1	60.2	0.4	1.0	98	95	8.4	12.7	8.2	12.1	50	59	
Max. 28th.....	58.0	75.0	58.0	75.0	0.0	0.0	100	100	11.3	20.3	11.3	20.3	58	75	
Min. 19th.....	54.0	48.0	54.0	48.0	0.0	0.0	100	100	9.7	7.6	9.7	7.6	54	48	
1923															
Mean.....	56.9	68.6	54.7	59.5	2.2	9.1	87	60	10.9	16.3	9.5	9.8	54	54	
Max. 16th.....	67.0	85.0	64.0	69.0	3.0	16.0	85	46	15.5	28.9	13.2	13.3	62	61	
Min. 7th.....	56.0	70.0	51.0	56.0	5.0	14.0	72	42	10.5	17.1	7.6	7.2	47	46	

TABLE IX (Continued)

CHURCHILL—SPECIFIC HUMIDITY—JUNE

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.			
1937															
Mean.....	41.5	46.7	40.1	43.9	1.4	2.8	88	80	5.5	6.9	4.8	5.5	37.1	38	41
Max. 30th.....	54.1	65.1	50.9	57.8	3.5	7.3	79	65	8.9	13.2	7.0	8.6	36.0	48	52
Min. 27th.....	35.2	38.4	35.0	36.2	0.2	2.2	97	82	4.3	4.9	4.2	4.4	35.6	34	32
1936															
Mean *.....	39.7	44.6	38.6	42.6	1.1	2.0	92	86	5.2	6.3	4.8	5.4	34.7	38	40
Max. 21st.....	45.2	67.8	42.6	67.0	2.6	0.8	82	96	6.5	14.7	5.3	14.1	50.4	40	67
Min. 12th*.....	34.0	34.2	34.0	33.2	0.0	1.0	100	90	4.1	4.1	4.1	3.7	26.0	34	32
1935															
Mean.....	37.6	39.8	36.6	38.5	1.0	1.3	91	88	4.8	5.2	4.4	4.6	33.1	36	37
Max. 29th.....	36.8	58.0	36.2	57.1	0.6	0.9	95	94	4.6	10.4	4.4	9.8	35.0	36	56
Min. 2nd.....	29.8	29.9	29.8	29.9	0.0	0.0	100	100	3.4	3.4	3.4	3.4	26.4	30	30
1934															
Mean.....	38.5	41.0	37.0	39.3	1.5	1.7	87	89	4.9	5.5	4.3	4.9	32.7	34	37
Max. 7th.....	50.1	67.8	45.8	59.4	4.3	8.4	71	61	7.7	14.7	5.5	9.0	36.4	41	54
Min. 5th.....	32.9	31.2	30.4	28.9	2.5	2.3	76	76	3.9	3.6	3.0	2.7	29.9	27	25
1933															
Mean.....	38.4	41.5	37.5	39.8	0.9	1.7	91	86	4.9	5.5	4.5	4.7	32.8	36	38
Max. 30th.....	41.6	55.1	41.2	54.9	0.4	0.2	96	98	5.6	9.2	5.4	9.0	33.6	41	54
Min. 6th.....	32.8	30.3	32.7	30.2	0.1	0.1	98	98	3.8	3.2	3.7	3.1	27.7	32	29

*Last 23 days' observations.

TABLE IX (Continued)

WINNIPEG—SPECIFIC HUMIDITY—JULY

	t _d		t _w		t _d -t _w		R.H.		W _s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	
1937															
Mean.....	60.9	77.4	58.5	65.9	2.4	11.5	87	56	12.6	22.1	11.0	12.4	63.4	57	60
Max. 10th.....	65.4	74.0	64.6	69.0	0.8	5.0	96	78	14.7	19.7	14.1	15.4	64	64	67
Min. 27th.....	62.0	76.0	58.6	60.6	3.4	15.4	82	41	13.0	21.0	10.7	8.6	48.4	56	51
1936															
Mean.....	66.2	82.9	62.2	69.7	4.0	13.2	81	53	15.1	27.9	12.2	14.8	75.8	60	64
Max. 10th.....	75.6	91.6	69.0	79.2	5.6	12.4	77	59	20.5	36.0	15.8	21.2	75.8	67	75
Min. 29th.....	49.4	77.6	47.6	59.6	1.8	18.0	88	35	8.0	22.3	7.0	7.8	54.8	47	47
1935															
Mean.....	66.3	78.6	63.6	69.2	2.7	9.4	86	62	15.1	23.1	13.0	14.7	68.2	62	65
Max. 16th.....	67.8	85.0	64.8	79.2	3.0	5.8	85	78	15.9	28.9	13.5	22.6	68.2	63	77
Min. 31st.....	63.4	73.4	60.0	63.0	3.4	10.4	82	56	13.7	19.3	11.3	10.8	57.4	58	57
1934															
Mean.....	58.6	74.0	55.4	62.6	3.2	12.3	82	50	11.7	20.1	9.6	10.0	54.8	53	56
Max. 28th.....	55.8	71.8	50.4	66.0	5.4	5.8	69	74	10.4	18.2	7.2	13.5	44.6	46	63
Min. 4th.....	61.6	63.8	60.2	53.8	1.4	10.0	92	52	12.8	13.8	11.8	7.2		60	46
1933															
Mean.....	61.7	76.6	58.8	65.4	2.9	11.2	84	55	12.9	21.5	10.8	11.8	69.4	57	59
Max. 10th.....	69.4	88.2	68.8	75.8	0.6	12.4	97	57	16.8	32.0	16.3	18.4	69.4	68	71
Min. 22nd.....	58.2	67.4	55.0	56.4	3.2	11.0	82	50	11.4	16.2	9.3	8.1	52.6	53	48
1932															
Mean.....	59.6	73.8	57.5	65.2	2.1	8.6	88	63	12.0	19.6	13.5	12.3	68.0	56	61
Max. 19th.....	72.2	85.0	67.4	77.0	4.8	8.0	79	70	18.4	28.9	12.6	20.2	41.0	65	74
Min. 1st.....	55.0	62.0	52.6	55.2	2.4	6.8	86	65	10.0	13.0	8.6	8.4		51	50
1931															
Mean.....	60.7	73.9	57.8	64.7	2.9	9.2	84	62	12.5	19.6	10.5	12.1	59.6	56	60
Max. 27th.....	65.8	89.0	59.8	76.8	6.0	12.2	71	56	14.9	33.0	10.6	18.5	59.6	56	72
Min. 3rd.....	53.5	66.6	51.0	57.2	2.5	9.4	85	61	9.4	15.3	8.0	9.3	55.0	48	51
1930															
Mean.....	63.6	76.3	60.7	67.0	2.9	9.3	85	62	13.8	21.2	11.7	12.9	66.0	59	51
Max. 8th.....	73.2	86.0	71.0	77.5	2.2	8.5	90	66	19.1	29.9	17.2	19.8	66.0	70	74
Min. 13th.....	53.0	68.2	50.0	57.8	3.0	10.4	82	53	9.2	16.1	7.5	8.5	52.0	47	50
1929															
Mean.....	60.4	75.6	57.5	66.9	2.9	8.7	84	65	12.4	20.7	10.4	13.5	62.0	56	62
Max. 11th.....	64.0	82.2	61.0	76.4	3.0	5.8	85	77	14.0	26.3	11.9	20.2	62.0	59	75
Min. 1st.....	52.0	65.4	50.5	58.0	1.5	7.4	91	64	8.8	14.7	8.0	9.4	46.8	49	53
1928															
Mean.....	61.2	72.0	59.2	63.2	2.0	8.8	89	62	12.7	18.3	11.3	11.3	65.0	58	58
Max. 15th.....	68.0	85.0	65.0	75.0	3.0	10.0	85	63	16.0	28.9	13.6	18.2	65.0	63	71
Min. 31st.....	54.5	63.4	51.8	55.5	2.7	7.9	83	61	9.8	13.7	8.1	8.4	48.0	49	51

TABLE IX (Continued)

MINNEDOSA—SPECIFIC HUMIDITY—JULY

	t_d		t_{ur}		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	
1937															
Mean.....	58.4	75.3	56.2	64.7	2.2	10.6	88	58	11.5	20.5	10.1	11.9	55	59	
Max. 5th.....	66.7	92.6	60.7	74.7	6.0	17.9	72	45	15.3	37.2	11.0	16.2	58	68	
Min. 27th.....	64.2	72.9	60.7	56.7	3.5	16.2	83	37	14.1	18.9	11.7	7.0	59	45	
1936															
Mean.....	64.4	79.7	60.6	66.6	3.8	13.1	81	51	14.2	24.0	11.5	12.2	60	60	
Max. 16th.....	73.9	89.6	65.2	78.6	8.7	11.0	64	62	19.6	35.7	12.5	20.9	61	75	
Min. 27th.....	59.7	72.7	53.2	59.7	6.5	13.0	66	48	12.1	18.8	8.0	9.0	49	52	
1935															
Mean.....	63.4	75.7	61.5	68.7	1.9	7.0	90	71	13.7	20.1	12.3	14.6	61	66	
Max. 28th.....	62.7	82.6	60.7	75.2	2.0	7.4	90	72	13.4	26.6	12.1	19.1	60	73	
Min. 5th.....	62.2	62.2	60.9	58.7	1.3	3.5	93	82	13.1	13.1	12.2	10.7	60	56	
1934															
Mean.....	57.1	72.7	53.8	60.9	3.3	11.8	81	51	10.9	18.8	8.8	9.6	52	54	
Max. 23rd.....	64.9	83.8	60.9	78.7	4.0	5.1	80	81	14.4	27.8	11.5	22.6	60	77	
Min. 27th.....	51.7	72.0	48.2	56.7	3.5	15.3	79	38	8.7	18.3	6.9	7.0	45	45	
1933															
Mean.....	59.6	75.8	56.9	65.0	2.7	10.8	86	57	12.0	20.8	10.3	11.8	55	59	
Max. 9th.....	63.7	82.6	61.7	78.5	2.0	4.1	90	84	13.8	26.6	12.4	22.4	61	78	
Min. 31st.....	49.7	58.9	46.5	49.9	3.2	9.0	80	54	8.1	11.7	6.5	6.3	43	42	
1932															
Mean.....	58.0	71.5	55.9	64.2	2.1	7.3	88	68	11.3	18.0	9.9	12.2	55	61	
Max. 18th.....	69.7	79.6	67.4	74.9	2.3	4.7	89	81	16.9	23.8	15.0	19.3	66	73	
Min. 9th.....	62.4	63.7	57.7	55.9	4.7	7.8	76	62	13.2	13.8	10.0	8.5	54	51	
1931															
Mean.....	57.8	73.2	55.3	64.4	2.5	8.8	86	62	11.2	19.1	9.6	11.8	58	73	
Max. 24th.....	65.7	95.6	61.9	82.9	3.8	12.7	81	59	14.8	40.8	12.0	24.1	60	80	
Min. 7th.....	50.7	62.1	46.7	53.0	4.0	9.1	75	55	8.4	13.0	6.3	7.2	43	47	
1930															
Mean.....	60.2	72.9	58.4	66.4	1.8	6.5	90	71	12.3	18.9	11.1	13.4	57	63	
Max. 8th.....	69.2	83.6	67.6	78.5	1.6	5.1	93	80	16.7	27.6	15.5	22.1	67	78	
Min. 6th.....	55.3	75.7	53.7	62.7	1.6	13.0	91	50	10.1	20.8	9.2	10.4	53	56	
1929															
Mean.....	57.5	75.4	55.0	64.8	2.5	10.6	86	59	11.1	20.6	9.6	12.2	54	59	
Max. 23rd.....	56.2	83.1	54.7	76.3	1.5	5.8	91	78	10.6	27.1	9.7	21.1	54	76	
Min. 3rd.....	56.9	72.5	54.7	57.5	2.2	15.0	88	40	10.9	18.7	9.6	7.5	54	48	
1928															
Mean.....	57.3	68.5	56.2	64.2	1.1	4.3	93	80	11.0	16.3	10.2	13.0	55	62	
Max. 15th.....	64.0	83.1	63.0	75.7	1.0	7.4	95	71	14.0	27.1	13.7	19.2	63	73	
Min. 8th.....	56.7	58.5	55.9	55.7	0.8	2.8	96	84	10.8	11.5	10.4	9.7	56	54	
1923															
Mean.....	60.8	70.9	59.3	65.5	1.5	5.4	92	75	12.5	17.6	11.5	13.2	59	63	
Max. 21st.....	65.7	84.9	65.1	77.5	0.6	7.4	97	73	14.9	28.8	14.5	21.0	65	75	
Min. 1st.....	52.9	64.8	50.0	53.5	2.9	11.3	83	49	9.2	14.4	7.6	7.1	48	45	

TABLE IX (Continued)

THE PAS—SPECIFIC HUMIDITY—JULY

	t_d		t_r		$t_d - t_r$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	19h.
1937															
Mean.....	58.6	77.4	56.3	65.4	2.3	12.0	88	52	10.6	20.4	9.3	10.6	55.6	54	58
Max. 26th.....	62.0	82.0	53.0	73.0	9.0	9.0	55	65	12.0	24.0	6.6	15.6	52.0	46	69
Min. 22nd.....	60.0	73.0	55.0	58.0	5.0	15.0	73	40	11.2	17.8	8.2	7.1	46.0	51	47
1936															
Mean.....	60.8	77.2	59.3	68.5	1.5	8.7	92	64	11.5	20.4	10.6	13.1	58.6	59	64
Max. 11th.....	70.0	91.0	69.0	82.0	1.0	9.0	95	68	15.9	32.6	15.1	22.2	68.0	69	79
Min. 1st.....	54.0	67.0	52.0	58.0	2.0	9.0	88	58	8.9	10.5	7.8	6.1	47.0	50	52
1935															
Mean.....	61.4	74.4	59.9	65.7	1.5	8.7	92	63	11.8	18.6	10.9	11.7	58.6	59	61
Max. 19th.....	60.0	68.0	60.0	68.0	0.0	0.0	100	100	11.2	15.0	11.2	15.0	58.0	60	68
Min. 12th.....	56.0	80.0	56.0	63.0	0.0	17.0	100	38	9.6	22.6	9.6	8.6	58.0	56	52
1934															
Mean.....	57.0	70.0	55.0	61.7	2.0	8.3	88	63	10.0	16.0	8.8	10.1	53.9	54	56
Max. 17th.....	70.0	81.0	64.0	72.0	6.0	9.0	72	64	16.0	23.3	11.5	14.9	59.0	61	68
Min. 4th.....	49.0	62.0	46.0	52.0	3.0	10.0	80	50	7.4	12.0	5.9	6.0	47.0	43	43
1933															
Mean.....	59.7	70.8	58.1	66.4	1.6	4.4	92	79	11.0	16.5	10.1	13.0	53.1	58	64
Max. 2nd.....	68.0	86.0	66.0	79.0	2.0	7.0	90	74	14.8	27.5	13.3	20.4	58.0	65	77
Min. 31st.....	50.0	54.0	49.0	53.0	1.0	1.0	93	94	7.7	8.9	7.2	8.4	42.0	48	52
1932															
Mean.....	60.4	72.0	59.2	65.5	1.2	6.5	93	71	11.3	17.1	10.5	12.1	54.5	58	62
Max. 18th.....	65.0	81.0	64.0	80.0	1.0	1.0	95	96	13.2	23.3	12.5	22.4	61.0	63	80
Min. 3rd.....	58.0	68.0	53.0	55.0	5.0	13.0	72	43	10.3	14.8	7.4	6.4	48.0	49	44
1931															
Mean.....	58.7	70.6	57.0	64.0	1.7	6.6	92	71	10.7	16.1	9.8	11.4	53.5	57	61
Max. 23rd.....	68.0	91.0	67.0	90.0	1.0	1.0	95	96	14.8	32.6	14.0	31.3	65.0	67	90
Min. 7th.....	52.0	62.0	49.0	54.0	3.0	8.0	81	60	8.3	12.0	6.7	7.2	43.0	46	52
1930															
Mean.....	60.6	71.8	59.2	67.9	1.4	3.9	92	82	11.3	16.9	10.4	12.9	54.0	58	66
Max. 8th.....	70.0	85.0	69.0	84.0	1.0	1.0	95	96	16.0	26.5	15.2	25.4	64.0	69	84
Min. 12th.....	60.0	59.0	58.0	54.0	2.0	5.0	89	73	11.1	10.8	9.9	7.9	45.0	57	50
1929															
Mean.....	58.0	70.9	56.2	66.0	1.8	4.9	90	77	10.4	16.5	9.4	12.7	50.5	55	63
Max. 14th.....	61.0	86.0	60.0	84.0	1.0	2.0	94	92	11.5	27.8	10.8	25.6	62.0	59	83
Min. 3rd.....	54.0	58.0	52.0	54.0	2.0	4.0	88	77	8.9	10.4	7.8	8.0	50.0	50	51
1928															
Mean.....	59.6	71.8	57.2	65.4	2.4	6.4	86	71	11.0	17.0	9.5	12.1	52.0	56	62
Max. 22nd.....	60.0	82.0	58.0	81.0	2.0	1.0	89	96	11.1	24.0	9.9	23.0	65.0	57	81
Min. 25th.....	59.0	58.0	57.0	53.0	2.0	5.0	89	72	10.8	10.4	9.6	7.5	49.0	56	49

TABLE IX (Continued)

QU'APPELLE—SPECIFIC HUMIDITY—JULY

	t_d		t_w		$t_d - t_w$		R.H.		W.		W		Min. Temp. Next 7h.		Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.
1937																
Mean	59.0	78.5	54.9	62.5	4.1	16.0	77	40	11.6	22.5	8.9	8.9	52	53	52	53
Max. 11th	66.0	84.8	62.2	63.0	3.8	1.8	82	91	14.8	12.8	12.1	11.6	60	62	60	62
Min. 7th	51.0	80.0	46.0	60.0	5.0	26.0	70	71	8.6	29.3	6.0	5.0	41	41	41	41
1936																
Mean	62.1	81.0	58.9	67.9	3.2	13.1	83	52	13.0	25.2	10.8	13.1	56	62	56	62
Max. 14th	64.5	78.0	64.0	73.0	0.5	5.0	98	79	14.2	22.6	7.7	17.9	64	71	64	71
Min. 1st	48.2	65.0	47.6	56.4	0.6	8.6	96	60	7.7	14.5	7.4	8.7	47	50	47	50
1935																
Mean	60.0	75.4	57.6	65.6	2.4	9.8	87	60	12.2	20.6	10.6	12.4	56	61	56	61
Max. 28th	67.0	91.0	66.0	76.0	1.0	15.0	95	51	15.5	35.3	14.7	18.0	51.0	70	66	70
Min. 31st	55.0	73.0	51.4	60.0	3.6	13.0	79	48	10.0	19.0	7.9	9.1	55.0	52	49	52
1934																
Mean	56.3	74.3	52.0	59.9	4.3	14.4	76	44	10.2	19.8	7.8	8.7	49	53	49	53
Max. 22nd	64.0	74.0	60.8	70.0	3.2	4.0	84	83	14.0	19.7	11.8	11.6	54.0	68	59	68
Min. 5th	49.0	55.0	47.0	45.0	2.0	10.0	87	46	7.9	10.0	6.9	4.6	32.0	34	45	34
1933																
Mean	56.6	74.0	53.6	61.8	3.0	12.2	83	51	10.7	19.7	8.9	10.0	52	55	52	55
Max. 10th	62.0	80.0	60.0	71.0	2.0	9.0	90	65	13.0	24.3	11.7	15.8	59	67	59	67
Min. 31st	45.0	59.0	43.0	50.0	2.0	9.0	86	54	6.7	11.7	5.7	6.3	41	42	41	42
1932																
Mean	56.9	73.1	54.6	62.5	2.3	10.6	86	55	10.8	19.1	9.3	10.5	53	57	53	57
Max. 19th	63.0	81.0	62.0	72.0	1.0	9.0	95	64	13.5	25.2	12.8	16.1	57.0	68	61	68
Min. 29th	56.0	79.0	51.0	60.0	5.0	19.0	71	31	10.0	23.4	7.1	7.3	57.0	47	47	47
1931																
Mean	58.2	74.1	54.0	60.4	4.2	13.7	77	46	11.4	19.8	8.8	9.1	51	51	51	51
Max. 26th	63.0	91.0	60.0	74.0	3.0	17.0	85	44	13.5	35.3	11.5	15.5	69.0	67	58	67
Min. 2nd	57.0	61.0	47.0	51.0	10.0	10.0	48	51	10.9	12.6	5.2	6.4	40.0	42	36	42
1930																
Mean	57.0	75.1	54.4	65.0	2.6	10.1	86	59	10.9	20.4	9.4	12.0	53	60	53	60
Max. 7th	63.0	84.0	62.0	74.0	1.0	10.0	95	63	13.5	28.0	12.8	17.6	55.0	70	61	70
Min. 28th	51.0	65.0	51.0	56.0	0.0	9.0	100	58	8.5	14.5	8.5	8.3	47.0	50	51	50
1929																
Mean	56.2	75.7	52.1	63.0	4.1	12.7	76	50	10.6	20.8	8.1	10.4	49	56	49	56
Max. 10th	57.0	85.0	52.0	82.0	5.0	3.0	72	88	18.3	28.9	13.2	25.4	51.0	81	48	81
Min. 12th	50.0	66.0	45.0	54.0	5.0	12.0	69	46	8.2	15.0	5.7	6.9	43.0	45	40	45
1928																
Mean	56.5	69.6	56.4	67.5	0.1	2.1	99	90	10.7	16.9	10.6	15.2	56	66	56	66
Max. 14th	64.0	81.0	64.0	80.0	0.0	1.0	100	95	14.0	25.2	14.0	23.9	62.0	80	64	80
Min. 2nd	58.0	58.0	58.0	58.0	0.0	0.0	100	100	11.3	11.3	11.3	11.3	55.0	58	58	58
1923																
Mean	60.4	70.9	59.0	64.6	1.4	6.3	92	71	12.4	17.6	11.4	12.5	62.0	61	58	61
Max. 20th	66.0	77.0	65.0	75.0	1.0	2.0	95	91	15.0	21.8	14.7	19.8	65	74	65	74
Min. 29th	47.0	57.0	46.0	52.0	1.0	5.0	93	71	7.3	10.9	6.8	7.6	43.0	48	45	48

TABLE IX (Continued)

CHURCHILL—SPECIFIC HUMIDITY—JULY

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	
1937															
Mean	54.7	61.9	53.5	58.0	1.2	3.9	93	79	9.0	11.9	8.4	9.4	48.7	53	55
Max. 29th	50.6	74.5	50.3	74.5	0.3	0.0	98	100	7.9	18.6	7.8	18.6	52.3	49	74
Min. 8th	49.2	54.0	47.0	48.6	2.2	5.4	85	67	7.5	8.9	6.4	6.0	47.2	45	43
1936															
Mean	54.0	60.4	52.4	56.0	1.6	3.8	91	78	8.9	11.6	8.1	9.0	49.2	51	53
Max. 29th	59.0	72.6	57.7	71.2	1.3	1.4	93	93	10.8	17.4	10.0	16.2	58.6	57	71
Min. 15th	43.7	43.9	43.2	43.1	0.5	0.8	96	93	6.0	5.5	5.8	5.1	42.3	43	42
1935															
Mean	49.9	56.6	48.5	53.8	1.4	2.8	90	83	7.7	6.0	6.9	5.0	43.4	47	52
Max. 25th	50.9	83.7	50.0	82.3	0.9	1.4	94	94	7.9	25.4	7.4	23.9	57.3	49	82
Min. 11th	37.7	37.6	37.4	37.4	0.3	0.2	97	98	4.8	4.7	1.7	4.6	34.8	37	37
1934															
Mean	50.9	57.6	49.7	54.3	1.2	3.3	93	82	8.0	10.2	7.4	8.4	47.3	48	52
Max. 16th	60.2	73.2	56.4	71.1	3.8	2.1	78	91	11.1	17.9	8.7	16.3	57.8	53	70
Min. 12th	40.3	42.5	40.0	41.0	0.3	1.5	97	88	5.3	5.8	5.1	5.1	37.8	39	39
1933															
Mean	53.0	58.4	51.7	55.5	1.3	2.9	92	83	8.6	10.6	7.9	8.8	45.7	50	53
Max. 24th	55.2	73.4	54.1	73.0	1.1	0.4	94	98	9.3	18.0	8.7	17.6	52.2	53	72
Min. 11th	54.1	41.3	53.4	41.1	0.7	0.2	95	98	8.9	5.5	8.5	5.4	34.6	52	40

TABLE IX (Continued)

THE PAS—SPECIFIC HUMIDITY—AUGUST

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.
1937															
Mean.....	53.5	70.1	52.4	62.4	1.1	7.7	94	66	8.8	16.0	8.3	10.6	51.6	51	57
Max. 5th.....	60.0	79.0	58.0	72.0	2.0	7.0	89	71	11.1	21.6	9.9	15.3	47.0	57	69
Min. 29th.....	39.0	68.0	39.0	56.0	0.0	12.0	100	47	5.0	14.8	5.0	7.0	47.0	39	47
1936															
Mean.....	52.4	69.1	51.5	61.5	0.9	7.6	94	66	8.4	15.2	7.9	10.0	49.7	49	57
Max. 13th.....	64.0	78.0	62.0	70.0	2.0	8.0	90	67	12.8	20.8	11.5	13.9	57.0	61	66
Min. 23rd.....	42.0	58.0	42.0	52.0	0.0	6.0	100	67	5.7	10.4	5.7	7.0	42.0	42	47
1935															
Mean.....	51.5	64.4	50.8	57.8	0.7	6.6	94	68	8.1	13.0	7.6	8.8	48.6	49	53
Max. 23rd.....	64.0	74.0	63.0	71.0	1.0	3.0	95	86	12.8	18.3	12.2	15.7	56	62	70
Min. 30th.....	38.0	52.0	38.0	45.0	0.0	7.0	100	58	4.8	8.3	4.8	4.8	34.0	38	37
1934															
Mean.....	51.4	64.5	49.2	57.2	2.2	7.3	86	64	8.1	13.0	7.0	8.3	48.2	47	52
Max. 16th.....	55.0	78.0	55.0	71.0	0.0	7.0	100	71	9.1	20.7	9.1	14.7	54.0	55	68
Min. 30th.....	47.0	48.0	44.0	43.0	3.0	5.0	79	67	7.0	7.1	5.5	4.8	35.0	41	37
1933															
Mean.....	56.3	70.2	55.0	67.2	1.3	3.0	92	86	9.7	16.0	8.9	13.8	51.2	54	66
Max. 8th.....	60.0	84.0	59.0	79.0	1.0	5.0	94	80	11.1	25.8	10.4	20.6	50.0	58	77
Min. 26th.....	48.0	56.0	46.0	56.0	2.0	0.0	87	100	7.3	9.6	6.4	9.6	46.0	44	56
1932															
Mean.....	57.8	71.1	56.3	66.0	1.5	5.1	91	77	10.3	16.6	9.4	12.8	53.5	56	63
Max. 28th.....	61.0	79.0	59.0	78.0	2.0	1.0	89	96	11.5	21.6	10.2	20.7	60.0	58	78
Min. 31st.....	48.0	47.0	47.0	46.0	1.0	1.0	93	93	7.2	6.9	6.7	6.4	43.0	46	45
1931															
Mean.....	55.6	68.5	54.4	62.5	1.2	6.0	93	72	9.5	15.1	8.8	10.9	51.7	54	58
Max. 19th.....	60.0	77.0	59.0	72.0	1.0	5.0	94	79	11.1	20.3	10.4	16.0	63.0	58	70
Min. 28th.....	46.0	57.0	45.0	50.0	1.0	7.0	93	61	6.6	9.9	6.1	6.0	39.0	44	44
1930															
Mean.....	57.3	72.4	55.9	68.0	1.4	4.4	91	80	10.1	17.3	9.2	13.8	52.8	54	65
Max. 25th.....	66.0	90.0	65.0	87.0	1.0	3.0	95	89	13.7	31.3	13.0	27.9	55.0	64	86
Min. 31st.....	42.0	48.0	40.0	45.0	2.0	3.0	85	80	5.7	7.2	4.8	5.8	36.0	38	42
1929															
Mean.....	54.6	70.4	52.7	65.4	1.9	5.0	88	77	9.1	16.4	8.0	12.6	50.2	52	62
Max. 8th.....	59.0	86.0	57.0	84.0	2.0	2.0	89	92	10.8	27.5	9.6	25.3	58.0	56	83
Min. 24th.....	63.0	59.0	58.0	53.0	5.0	6.0	74	68	12.3	10.9	9.1	7.4	52.0	55	48
1928															
Mean.....	52.7	64.5	50.2	60.0	2.5	4.5	85	77	8.5	13.0	7.2	10.0	45.9	48	57
Max. 10th.....	63.0	88.0	60.0	85.0	3.0	3.0	84	88	12.3	29.5	10.3	26.0	69.0	58	84
Min. 22nd.....	48.0	51.0	46.0	48.0	2.0	3.0	87	81	7.2	8.0	6.3	6.5	43.0	44	45

TABLE IX (Continued)

CHURCHILL—SPECIFIC HUMIDITY—AUGUST

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.		7h.	19h.
1937															
Mean.....	48.2	55.3	48.4	53.5	0.1	1.8	99	89	7.2	9.3	7.1	8.3	44.8	47	52
Max. 12th.....	47.0	68.1	47.0	68.0	0.0	0.1	100	99	6.9	14.8	6.9	14.6	47.6	47	67
Min. 28th.....	38.9	43.8	38.9	42.3	0.0	1.5	100	89	4.9	6.0	4.9	5.3	32.1	39	41
1936															
Mean.....	49.5	55.1	48.2	51.2	1.3	3.9	91	76	7.6	9.2	6.9	7.0	47.0	46	48
Max. 28th.....	48.1	63.8	47.6	61.8	0.5	2.0	96	90	7.2	12.6	6.9	11.4	44.5	47	61
Min. 17th.....	51.2	47.2	50.9	44.3	0.3	2.9	98	79	8.0	7.0	7.8	5.5	43.1	51	41
1935															
Mean.....	48.8	54.9	48.2	52.4	0.6	2.5	96	85	7.4	9.2	7.1	7.8	44.4	48	51
Max. 23rd.....	45.0	67.4	44.5	67.1	0.5	0.3	96	97	6.4	14.4	6.1	14.0	50.2	44	66
Min. 3rd.....	42.1	42.1	41.8	42.0	0.3	0.1	98	98	5.7	5.7	5.6	5.6	40.8	42	41
1934															
Mean.....	46.5	53.0	45.5	50.1	1.0	0.9	93	94	6.8	8.6	6.3	8.1	43.8	44	51
Max. 29th.....	50.1	64.8	49.6	64.3	0.5	0.5	96	97	7.7	13.1	7.4	12.7	41.0	49	64
Min. 8th.....	48.2	50.1	48.1	44.2	0.1	5.9	98	62	7.2	7.8	7.1	4.8	41.3	47	37

TABLE IX (Concluded)

CHURCHILL—SPECIFIC HUMIDITY—SEPTEMBER

	t_d		t_w		$t_d - t_w$		R.H.		W_s		W		Min. Temp. Next 7h.	Dew Point	
	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.	7h.	19h.		7h.	19h.
1936															
Mean	40.0	46.4	38.9	44.0	1.1	2.4	92	83	5.2	6.8	4.8	5.6	37.8	38	41
Max. 4th	51.0	64.3	51.0	62.4	0.0	1.9	100	90	8.0	12.9	8.0	11.6	51.3	51	61
Min. 16th	33.0	38.2	32.9	33.5	0.1	4.7	98	61	3.9	4.9	3.8	3.0	32.8	32	27
1935															
Mean	39.4	43.1	38.6	41.4	0.8	1.7	94	87	5.1	6.0	4.8	5.2	37.2	37	40
Max. 1st	47.8	52.6	47.2	52.4	0.6	0.2	95	98	7.2	8.5	6.8	8.3	43.1	47	52
Min. 25th	29.8	29.4	29.7	29.0	0.1	0.4	98	95	3.4	3.3	3.3	3.1	25.4	29	28
1934															
Mean	36.3	41.1	35.9	40.1	0.4	1.0	95	92	4.6	5.5	4.4	5.1	34.1	35	39
Max. 7th	47.1	66.1	46.7	66.0	0.4	0.1	97	99	7.0	13.8	6.8	13.7	43.0	46	65
Min. 29th	26.8	26.3	26.6	26.2	0.2	0.1	97	98	2.9	2.8	2.8	2.7	23.9	26	25
1933															
Mean	41.5	46.6	40.8	44.6	0.7	2.0	94	86	5.6	6.8	5.3	5.8	38.6	40	43
Max. 15th	46.0	67.4	46.0	65.1	0.0	2.3	100	88	6.6	14.4	6.6	12.7	45.1	49	63
Min. 30th	35.0	34.0	34.0	32.0	1.0	2.0	91	81	4.3	4.1	3.9	3.3	28.2	33	29

TABLE X

AVERAGE RELATION BETWEEN FREQUENCY OF WARM AND COOL DAYS AND
VARIOUS WIND-DIRECTIONS
Number of Cases in Ten Julys

Mean Temp. of Day	45 to 50	50 to 55	55 to 60	60 to 65	65 to 70	70 to 75	75 to 80	80 to 85	85 to 90	90 to 95
				Wind—North						
Winnipeg..	0	0	0.9	4.5	6.4	3.6	0.9	0.9	0	0
Minnedosa..	0	0	0	1.8	2.7	0	0	0	0	0
The Pas..	0	1.0	11.0	17.0	15.0	5.0	1.0	0	0	0
				Wind—Northeast						
Winnipeg..	0	0	0.9	10.9	10.9	7.3	1.8	2.7	0.9	0
Minnedosa..	0	0.9	1.8	6.4	7.3	1.8	0	0.9	0	0
The Pas.....	0	0	7.0	17.0	7.0	7.0	0	0	0	0
				Wind—East						
Winnipeg.....	0	0	0.9	2.7	5.5	2.7	1.8	0	0	0
Minnedosa.....	0	0	5.5	3.6	4.5	6.4	0.9	0.9	0	0
The Pas.....	0	0	2.0	5.0	4.0	3.0	0	0	0	0
				Wind—Southeast						
Winnipeg.....	0	0	2.7	8.2	18.2	21.0	10.0	5.4	0.9	0.9
Minnedosa.....	0	1.8	9.1	9.1	14.5	7.3	2.7	0	0	0
The Pas.....	0	2.0	7.0	10.0	17.0	9.0	1.0	1.0	0	0
				Wind—South						
Winnipeg..	0	0	0.9	2.7	1.8	8.2	5.5	0	0	0.9
Minnedosa.....	0	0.9	0.9	2.7	2.7	1.8	2.7	0	0	0.9
The Pas.....	0	0	1.0	3.0	3.0	4.0	1.0	0	0	0
				Wind—Southwest						
Winnipeg..	0	0	0.9	0.9	9.1	11.8	3.6	0.9	0	0
Minnedosa.....	0	0	0	1.8	0.9	4.5	1.8	0	0	0
The Pas.....	0	0	4.0	6.0	6.0	5.0	0	0	0	0
				Wind—West						
Winnipeg..	0	0	1.8	6.4	9.1	3.6	3.6	0	0	0
Minnedosa.....	0	0	0	3.6	4.5	0.9	0.9	0	0	0
The Pas..	0	2.0	5.0	6.0	9.0	2.0	1.0	0	0	0
				Wind—Northwest						
Winnipeg.....	0	0.9	7.3	20.0	26.4	17.3	13.6	0	0	0
Minnedosa.....	0	2.7	11.8	15.5	25.5	8.2	1.8	0.9	0	0
The Pas.....	0	2.0	5.0	17.0	26.0	11.0	1.0	0	0	0
				Wind—Calm						
Winnipeg.....	0	0	2.7	8.2	5.5	1.8	0.9	0	0	0
Minnedosa.....	0	1.8	10.0	40.9	33.6	27.3	8.2	0	0	0
The Pas.....	0	0	6.0	13.0	10.0	10.0	1.0	0	0	0

TABLE XI

AVERAGE RELATION BETWEEN FREQUENCY OF COLD AND MILD DAYS AND
VARIOUS WIND-DIRECTIONS

Number of Cases in Ten Januaries

Mean Temp. of Day	-60 to -40	-40 to -20	-20 to Zero	Zero to 20	20 to 40	40 to 60
		Wind—North				
Winnipeg.....	0	2.7	22.7	14.5	1.8	0
Minnedosa.....	0	0	3.6	3.6	0.9	0
The Pas.....	0	5.0	22.0	6.0	3.0	0
		Wind—Northeast				
Winnipeg.....	0	0	6.4	5.4	0	0
Minnedosa.....	0	0	0.9	3.6	0	0
The Pas.....	0	5.0	21.0	5.0	2.0	0
		Wind—East				
Winnipeg.....	0	0	4.5	1.8	0	0
Minnedosa.....	0	0	9.1	2.6	0	0
The Pas.....	0	1.0	9.0	6.0	0	0
		Wind—Southeast				
Winnipeg.....	0	0	6.4	17.3	1.8	0
Minnedosa.....	0	0.9	7.3	7.3	0	0
The Pas.....	0	4.0	13.0	11.0	1.0	0
		Wind—South				
Winnipeg.....	0	7.3	22.7	25.4	10.0	0
Minnedosa.....	0	0.9	0.9	0	0	0
The Pas.....	0	8.0	5.0	9.0	2.0	0
		Wind—Southwest				
Winnipeg.....	0	1.8	14.6	8.2	3.6	0
Minnedosa.....	0	0	0.9	0	1.8	0
The Pas.....	0	9.0	11.0	7.0	1.0	0
		Wind—West				
Winnipeg.....	0	5.4	12.7	6.4	2.7	0
Minnedosa.....	0	2.7	11.8	7.3	2.7	0
The Pas.....	0	14.0	10.0	3.0	4.0	0
		Wind—Northwest				
Winnipeg.....	0	6.4	43.6	23.6	9.1	0
Minnedosa.....	0	8.2	44.5	23.6	13.6	0
The Pas.....	1.0	20.0	37.0	16.0	5.0	0
		Wind—Calm				
Winnipeg.....	0	2.7	9.1	8.2	0	0
Minnedosa.....	0	20.0	61.8	57.3	11.8	0
The Pas.....	0	21.0	14.0	0	0	0

TABLE XII

AVERAGE NUMBER OF THUNDERSTORMS PER MONTH

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Minnedosa (37 yrs.)...	0	0	.03	0.5	1.8	4.4	5.7	4.7	1.7	.22	.03	0
Norway House (27 yrs.)	0	0	0	0.2	0.5	1.8	3.6	2.3	0.4	.04	.04	0
Winnipeg (37 yrs.)	0	.03	.06	0.6	1.9	4.4	5.3	3.7	2.3	.30	.03	0
Brandon (38 yrs.)	0	0	0	0.2	1.1	1.6	2.0	1.7	0.7	.10	.03	0
Hillview (19 yrs.)	0	0	.05	0.4	1.9	3.9	5.0	4.3	1.7	.40	.15	0
Treesbank (36 yrs.)	0	0	.06	0.5	2.1	3.6	4.1	3.8	1.7	.30	.03	0
Treherne (32 yrs.)	0	0	0	0.6	1.9	3.5	4.0	3.0	1.6	.40	.03	0
Graysville and Almasippi	0	0	0	0.7	2.7	5.1	6.2	4.1	2.0	.40	.10	0
Moose Horn Bay.....	0	0	0	0.6	2.7	5.2	4.8	4.1	1.8	.20	0	0

NUMBER OF THUNDERSTORMS

MAXIMUM NUMBER

Yearly Mean	One Year	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
19.0	30	1	3	5	8	12	11	4	2	1
8.7	19	0	2	3	6	8	8	2	1	1
18.7	32	1	3	6	9	13	9	5	2	1
7.5	17	0	1	4	6	7	6	3	1	1
17.5	30	1	3	6	8	11	14	5	3	3
16.3	39	1	3	6	8	15	11	7	3	1
15.3	29	0	4	9	12	12	7	5	3	1

TABLE XIII

NORMAL MEAN DAILY MAXIMUM TEMPERATURE ° F.

Station	No. Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Berens River...	26	3.0	8.9	22.8	42.3	58.0	70.5	75.5	71.7	60.6	46.1	26.8	8.7
Birtle.....	23	6.5	13.6	27.7	46.3	62.1	71.1	77.0	74.7	64.1	48.9	12.1	12.1
Churchill.....	45	-10.9	-8.2	4.8	25.1	37.4	51.9	64.2	62.6	48.8	33.7	14.6	-
Dauphin.....	30	10.2	16.9	30.1	49.0	64.1	73.6	79.3	76.6	65.7	52.7	33.5	17.7
Flin Flon Mine.....	9	-0.2	8.8	23.2	42.6	59.5	68.4	76.0	72.2	57.1	42.2	20.8	7.5
Graysville.....	32	8.9	15.8	29.6	49.6	65.4	74.3	79.2	76.6	67.0	53.0	33.3	16.4
Minnedosa.....	50	9.0	13.1	27.0	48.6	63.2	72.0	76.7	74.6	64.4	50.3	30.4	16.2
Moose Horn Bay.....	19	4.8	14.2	24.0	44.9	60.1	70.0	75.4	72.4	62.2	48.0	28.9	13.0
Morden.....	32	13.1	21.3	30.1	49.9	64.6	73.7	79.1	77.1	67.2	53.2	30.1	17.3
Ninette.....	24	12.2	18.3	30.4	50.2	65.2	73.6	79.3	76.9	65.9	52.8	33.6	18.3
Norway House.....	36	-1.4	5.9	20.3	40.4	56.2	67.2	73.4	69.3	56.7	43.0	22.7	6.0
Pinawa.....	21	9.3	15.4	27.4	45.9	62.1	71.0	76.5	74.1	62.7	48.4	29.9	14.0
Russell.....	46	3.3	9.0	22.3	45.7	61.8	70.2	74.9	73.5	62.4	48.8	27.6	12.8
Souris.....	22	3.3	17.0	29.5	49.4	65.4	73.6	79.7	76.9	65.8	50.4	30.7	15.7
Sprague.....	20	10.7	17.4	28.8	47.4	63.3	72.3	77.9	74.8	64.0	48.9	30.4	9.0
The Pas.....	25	2.4	16.3	24.4	45.0	59.7	70.0	75.4	72.1	60.7	42.7	26.3	9.0
Trebank.....	52	9.5	14.5	30.2	51.3	66.6	76.6	82.0	79.4	67.7	51.7	31.8	16.9
Treherne.....	40	10.7	14.3	27.9	49.0	64.4	72.6	78.1	75.5	65.5	51.6	32.2	17.0
Virden.....	30	8.0	12.4	27.5	49.6	64.7	73.1	79.5	77.3	67.5	53.7	30.9	15.9
Winnipeg.....	50	8.0	12.4	27.5	49.6	64.7	73.1	79.5	77.3	67.5	53.7	30.9	15.9

NORMAL MEAN DAILY MINIMUM TEMPERATURE ° F.

Station	No. Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Berens River.....	26	-17.7	-14.5	-3.3	20.3	34.1	45.1	49.7	47.2	39.0	28.5	11.6	7.9
Birtle.....	23	-23.3	-4.7	7.7	25.3	36.9	47.0	51.6	47.8	39.5	28.0	12.8	2.2
Churchill.....	45	-27.0	-26.4	-17.2	4.5	20.8	33.1	41.6	41.4	33.2	19.2	1.1	-19.1
Dauphin.....	30	-8.7	-4.4	7.9	27.0	38.7	49.3	53.9	50.7	41.8	31.3	15.6	-0.1
Flin Flon Mine.....	9	-19.1	-13.1	-4.4	18.0	36.0	47.8	54.9	51.1	39.8	26.4	5.9	-8.8
Graysville.....	32	-8.6	-4.1	10.1	27.4	37.8	49.3	53.8	50.5	42.1	31.0	18.5	-0.0
Minnedosa.....	50	-11.8	-8.3	4.6	25.7	37.0	47.7	51.7	48.1	39.6	29.0	13.2	-2.3
Moose Horn Bay.....	19	-27.1	-6.7	0.9	24.7	37.1	49.3	54.9	50.5	42.2	30.6	13.8	-3.9
Morden.....	32	-5.3	0.9	17.4	27.9	39.3	51.1	55.6	52.0	44.1	31.9	16.4	2.9
Ninette.....	24	-7.0	-2.0	9.5	27.8	39.2	49.2	54.0	51.1	42.0	31.1	16.6	0.7
Norway House.....	36	-19.7	-15.6	-3.7	18.1	32.7	44.3	52.9	50.1	40.0	28.3	9.0	-10.0
Pinawa.....	21	-13.4	-9.8	3.5	24.4	37.1	46.1	53.4	50.6	42.7	30.9	15.1	-5.7
Russell.....	46	-12.9	-10.8	1.5	22.6	33.5	41.9	45.6	42.5	33.1	23.4	9.0	-4.2
Souris.....	22	-7.8	-2.8	9.2	28.0	39.1	48.9	54.3	51.2	41.4	29.5	15.8	-1.2
Sprague.....	20	-13.0	-7.0	6.0	25.7	38.2	47.6	52.0	46.8	38.7	27.5	12.6	-6.3
The Pas.....	25	-17.0	-14.4	2.5	20.9	35.7	48.5	53.2	49.0	37.6	25.4	8.6	-8.6
Trebank.....	52	-11.7	-8.6	5.4	26.6	37.6	49.0	53.3	50.0	41.0	29.0	13.2	-3.3
Treherne.....	40	-8.3	-4.7	7.2	26.3	38.3	48.9	53.5	50.9	42.2	31.0	14.9	-0.8
Virden.....	30	-11.2	-8.3	5.9	26.8	37.1	48.7	52.8	48.5	38.9	27.2	14.8	1.7
Winnipeg.....	50	-11.2	-8.3	5.9	26.8	37.1	48.7	52.8	48.5	38.9	27.2	14.8	1.7

TABLE XIV

NORMAL EXTREME MAXIMUM TEMPERATURE ° F.

Station	No. Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Berens River.....	26	26.5	33.2	43.9	62.6	76.3	85.2	89.4	84.0	75.4	64.2	43.2	32.8
Birtle.....	23	32.9	35.4	47.8	68.9	82.5	86.4	91.4	90.0	83.7	71.8	50.2	33.7
Churchill.....	45												
Dauphin.....	30	36.7	42.6	51.2	72.4	86.3	91.1	93.1	91.5	85.2	73.8	55.1	41.1
Flin Flon Mine.....	5	34.2	44.0	36.3	60.6	80.0	84.0	87.8	85.0	77.6	65.2	38.8	24.4
Graysville.....													
Minnetosa.....	31	33.6	37.2	48.0	70.7	82.7	88.0	91.2	89.9	83.8	72.6	50.8	36.9
Moose Horn Bay.....	19	31.9	38.8	44.7	66.2	82.6	85.9	85.8	85.0	78.4	68.6	47.9	36.9
Morden.....	30												
Ninette.....	24	37.5	41.3	50.4	71.7	85.9	89.9	93.0	93.0	87.3	78.4	54.3	41.0
Norway House.....	28	23.1	32.2	44.1	60.4	75.6	82.5	85.0	79.9	73.1	62.0	40.1	29.4
Pinawa.....	21	32.0	38.3	47.6	66.8	81.8	84.5	88.6	86.5	79.0	68.2	47.7	35.9
Russell.....	24	34.6	37.0	46.3	68.8	83.8	87.6	90.7	89.0	83.8	73.2	49.8	36.3
Souris.....	22	34.6	38.9	49.0	71.3	84.9	90.0	94.4	92.3	86.8	73.6	52.1	37.7
Sprague.....	20	33.6	39.3	49.0	68.2	84.0	86.7	90.2	88.9	82.0	71.9	49.4	38.3
The Pas.....	25	26.9	38.4	46.5	66.4	79.6	84.3	87.6	85.0	77.9	66.6	44.0	33.6
Treesbank.....	31	35.6	41.4	53.0	74.2	88.9	94.5	99.6	95.2	90.1	78.0	54.4	38.4
Treherne.....	29	35.0	38.4	48.9	70.8	85.1	89.5	94.2	92.5	86.1	72.2	52.8	38.4
Virden.....	30												
Winnipeg.....	30	32.0	37.4	48.3	71.1	85.3	89.8	91.5	91.9	85.1	73.6	50.8	37.0

NORMAL EXTREME MINIMUM TEMPERATURE ° F.

Station	No. Years	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Berens River.....	26	-39.9	-37.2	-28.1	-4.7	17.7	30.6	37.4	34.2	26.2	13.3	-13.3	-33.6
Birtle.....	23	-35.8	-33.3	-19.5	6.9	20.1	32.4	39.2	32.5	23.6	9.8	-11.5	-33.2
Churchill.....													
Dauphin.....	30	-33.3	-28.5	-17.8	7.2	21.5	34.9	42.8	37.0	27.5	15.0	-7.0	-26.0
Flin Flon Mine.....	5	-40.4	-33.0	-24.8	-6.0	23.6	37.4	47.2	40.6	28.6	8.4	-15.4	-33.6
Graysville.....													
Minnetosa.....	31	-37.4	-32.7	-19.7	5.8	20.7	32.4	39.8	33.7	24.5	10.7	-5.9	-29.9
Moose Horn Bay.....	19	-39.7	-35.6	-25.1	4.2	19.9	31.9	39.4	34.8	25.7	12.0	-7.4	-29.3
Morden.....	30												
Ninette.....	24	-33.0	-27.8	-17.0	8.9	22.8	33.5	43.5	38.4	28.8	15.1	-4.1	-26.9
Norway House.....	26	-43.5	-42.5	-35.2	11.5	23.4	35.8	43.5	34.1	24.7	13.8	-4.1	-26.5
Pinawa.....	21	-26.5	-37.8	-26.3	9.5	16.9	30.8	40.9	34.8	25.2	12.1	-9.2	-29.9
Russell.....	24	-40.7	-35.7	-24.9	2.5	21.3	31.3	40.0	36.1	27.5	15.4	-9.0	-29.9
Souris.....	22	-36.1	-29.5	-17.9	9.7	24.6	34.8	42.0	34.5	25.6	12.6	-5.6	-28.6
Sprague.....	20	-41.3	-36.8	-24.6	4.6	21.9	29.6	35.3	29.7	20.6	11.4	-13.3	-36.0
The Pas.....	25	-41.4	-36.4	-27.4	1.1	20.7	33.5	39.9	36.2	25.4	11.5	-14.2	-32.4
Treesbank.....	31	-36.8	-30.8	-18.6	7.5	19.6	32.4	41.3	34.2	24.9	11.1	-9.7	-29.4
Treherne.....	29	-33.1	-28.5	-15.7	10.0	20.7	33.6	40.9	36.6	26.8	13.5	-6.5	-26.0
Virden.....	30												
Winnipeg.....	30	-33.7	-28.7	-16.4	10.2	22.3	34.9	43.7	37.9	28.8	16.1	-4.5	-26.2

TABLE XV

DIFFERENCES OF MEAN DAILY MAXIMUM
AND MINIMUM TEMPERATURES FROMNORMAL
WINNIPEG
January

Year	Maximum		Minimum	
	Mean	Diff.	Mean	Diff.
1873	4.2	-3.2	*	*
1874	7.4	0.0	-15.7	-3.6
1875	-5.9	-13.3	-26.7	-14.6
1876	5.3	-2.1	-16.5	-4.4
1877	4.2	-3.2	-19.2	-7.1
1878	18.6	11.2	*	*
1879	7.3	-0.1	-14.1	-2.0
1880	12.8	5.4	-20.1	-8.0
1881	1.2	-6.2	*	*
1882	*	*	*	*
1883	*	*	*	*
1884	*	*	*	*
1885	*	*	*	*
1886	-5.3	-12.7	-24.5	-12.4
1887	-3.6	-11.0	-26.7	-14.6
1888	-4.8	-12.2	-23.4	-11.3
1889	15.6	8.2	-5.1	7.0
1890	-2.9	-10.3	-22.3	-10.2
1891	15.5	8.1	-2.6	9.5
1892	2.9	-4.5	-17.4	-5.3
1893	1.9	-5.5	-21.6	-9.5
1894	4.9	-2.5	-18.2	-6.1
1895	2.2	-5.2	-17.3	-5.2
1896	9.4	2.0	-16.8	-4.7
1897	8.5	1.1	-12.0	0.1
1898	15.3	7.9	-7.9	4.2
1899	5.7	-1.7	-15.2	-3.1
1900	17.5	10.1	-4.4	7.7
1901	7.6	0.2	-14.5	-2.4
1902	19.3	11.9	-4.3	7.8
1903	13.6	6.2	-9.0	3.1
1904	7.4	0.0	-13.4	-1.3
1905	5.7	-1.7	-16.0	-3.9
1906	17.0	9.6	-3.3	8.8
1907	-1.1	-8.5	-21.6	-9.5
1908	17.8	10.4	-2.3	9.8
1909	7.5	0.1	-12.5	-0.4
1910	13.9	6.5	-3.2	8.9
1911	-0.9	-8.3	-19.3	-7.2
1912	-3.1	-10.5	-19.9	-7.8
1913	1.3	-6.1	-13.5	-1.4
1914	16.7	9.3	-1.4	10.7
1915	7.9	0.5	-7.0	5.1
1916	1.8	-5.6	-15.4	-3.3
1917	0.3	-7.1	-16.1	-4.0
1918	2.0	-5.4	-12.5	-0.4
1919	19.1	11.7	2.9	15.0
1920	3.8	-3.6	-11.8	0.3
1921	16.5	9.1	-2.2	9.9
1922	12.0	4.6	-6.0	6.1
1923	11.6	4.2	-7.5	4.6
1924	4.8	-2.6	-11.9	0.2
1925	8.0	0.6	-7.1	5.0
1926	14.5	7.1	-2.5	9.6
1927	9.0	1.6	-4.8	7.3
1928	15.7	8.3	1.3	13.4
1929	-2.5	-9.9	-17.5	-5.4
1930	0.0	-7.4	-14.7	-2.6
1931	17.2	9.8	2.7	14.8
1932	14.4	7.0	-1.9	10.2
1933	12.0	4.6	-7.3	4.8
1934	17.6	10.2	-5.9	6.2
1935	1.6	-5.8	-16.9	-4.8
1936	-3.1	-10.5	-23.2	-11.1

A 7.4 B 7.36 A -12.1 B 7.80

A = Mean Value

B = Standard Deviation

*Records incomplete

TABLE XV (Continued)
DIFFERENCES OF MEAN DAILY MAXIMUM
AND MINIMUM TEMPERATURES FROM
NORMAL
WINNIPEG
May

Year	Maximum		Minimum	
	Mean	Diff.	Mean	Diff.
1872	59.6	-5.2	38.5	-1.0
1873	65.9	1.1	39.7	0.2
1874	70.7	5.9	40.9	1.4
1875	67.6	2.8	39.2	-0.3
1876	66.3	1.5	39.9	0.4
1877	67.8	3.0	42.9	3.4
1878	59.2	-5.6	36.9	-2.6
1879	65.6	0.8	42.3	2.8
1880	64.9	0.1	44.0	4.5
1881	69.1	4.3	43.6	4.1
1882	62.7	-2.1	36.9	-2.6
1883	58.1	-6.7	35.0	-4.5
1884	62.2	-2.6	40.1	0.6
1885	62.2	-2.6	38.0	-1.5
1886	68.0	3.2	38.7	-0.8
1887	68.7	3.9	42.5	3.0
1888	59.9	-4.9	30.2	-9.3
1889	64.9	0.1	34.0	-5.5
1890	55.2	-9.6	30.4	-9.1
1891	64.9	0.1	34.7	-4.8
1892	55.6	-9.2	36.0	-3.5
1893	64.0	-0.8	38.0	-1.5
1894	65.8	1.0	40.2	0.7
1895	67.3	2.5	40.8	1.3
1896	63.6	-1.2	44.5	5.0
1897	67.8	3.0	38.3	-1.2
1898	68.4	3.6	37.9	-1.6
1899	62.0	-2.8	39.0	-0.5
1900	74.2	9.4	40.4	0.9
1901	73.1	8.3	43.4	3.9
1902	65.9	1.1	44.2	4.7
1903	67.8	3.0	40.6	1.1
1904	67.3	2.5	39.7	0.2
1905	62.5	-2.3	38.3	-1.2
1906	61.6	-3.2	36.2	-3.3
1907	51.8	-13.0	27.7	-11.8
1908	64.5	-0.3	39.9	0.4
1909	64.5	-0.3	39.2	-0.3
1910	62.5	-2.3	35.4	-4.1
1911	67.8	3.0	42.4	2.9
1912	64.7	-0.1	42.4	2.9
1913	61.7	-3.1	38.2	-1.3
1914	68.0	3.2	42.4	2.9
1915	66.0	1.2	39.6	0.1
1916	61.4	-3.4	37.8	-1.7
1917	67.0	2.2	35.2	-4.3
1918	62.2	-2.6	36.7	-2.8
1919	71.6	6.8	43.8	4.3
1920	67.9	3.1	40.8	1.3
1921	66.9	2.1	41.6	2.1
1922	71.7	6.9	48.4	8.9
1923	67.3	2.5	41.5	2.0
1924	56.9	-7.9	32.7	-6.8
1925	63.5	-1.3	38.2	-1.3
1926	70.4	5.6	45.2	5.7
1927	56.3	-8.5	40.9	1.4
1928	69.4	4.6	42.4	2.9
1929	59.0	-5.8	36.4	-3.1
1930	60.1	-4.7	40.7	1.2
1931	61.0	-3.8	39.0	-0.5
1932	67.5	2.7	42.3	2.8
1933	67.0	2.2	42.4	2.9
1934	69.6	4.8	42.9	3.4
1935	61.6	-3.2	39.9	0.4
1936	71.2	6.4	43.8	4.3
	A 64.8	B 4.57	A 39.5	B 3.74

A = Mean Value
B = Standard Deviation

TABLE XV (Continued)
DIFFERENCES OF MEAN DAILY MAXIMUM
AND MINIMUM TEMPERATURES FROM
NORMAL
WINNIPEG
July

Year	Maximum		Minimum	
	Mean	Diff.	Mean	Diff.
1873	77.7	-0.7	52.4	-2.6
1874	82.0	3.6	54.2	-0.8
1875	80.2	1.8	51.6	-3.4
1876	81.1	2.7	53.1	-1.9
1877	81.3	2.9	57.3	2.3
1878	82.1	3.7	56.8	1.8
1879	79.5	1.1	56.6	1.6
1880	78.5	0.1	52.5	-2.5
1881	82.1	3.7	55.2	0.2
1882	74.6	-3.8	53.0	-2.0
1883	74.6	-3.8	50.0	-5.0
1884	69.4	-9.0	49.6	-5.4
1885	75.0	-3.4	53.2	-1.8
1886	84.3	5.9	55.0	0.0
1887	78.8	0.4	53.3	-1.7
1888	78.2	-0.2	53.4	-1.6
1889	75.2	-3.2	52.0	-3.0
1890	80.1	1.7	54.6	-0.4
1891	72.9	-5.5	49.5	-5.5
1892	76.0	-2.4	53.2	-1.8
1893	77.8	-0.6	55.4	0.4
1894	81.3	2.9	54.8	-0.2
1895	75.8	-2.6	51.6	-3.4
1896	75.9	-2.5	53.7	-1.3
1897	79.0	0.6	56.8	1.8
1898	77.4	-1.0	54.0	-1.0
1899	79.0	0.6	54.2	-0.8
1900	78.0	-0.4	51.7	-3.3
1901	80.2	1.8	58.3	3.3
1902	80.0	1.6	55.7	0.7
1903	77.8	-0.6	52.9	-2.1
1904	74.4	-4.0	53.2	-1.8
1905	76.6	-1.8	54.0	-1.0
1906	77.1	-1.3	56.3	1.3
1907	71.9	-6.5	55.5	0.5
1908	74.3	-4.1	54.1	-0.9
1909	78.6	0.2	56.0	1.0
1910	75.6	-2.8	55.6	0.6
1911	74.3	-4.1	53.1	-1.9
1912	70.0	-8.4	55.1	0.1
1913	75.3	-3.1	53.5	-1.5
1914	83.9	5.5	60.5	5.5
1915	74.1	-4.3	51.5	-3.5
1916	83.3	4.9	61.1	6.1
1917	81.0	2.6	57.2	2.2
1918	76.6	-1.8	50.9	-4.1
1919	80.9	2.5	57.1	2.1
1920	79.6	1.2	53.3	-1.7
1921	81.9	3.5	59.0	4.0
1922	77.7	-0.7	54.7	-0.3
1923	83.2	4.8	59.7	4.7
1924	77.4	-1.0	54.7	-0.3
1925	78.3	-0.1	54.9	-0.1
1926	80.1	1.7	55.8	0.8
1927	76.7	-1.7	54.3	-0.7
1928	77.1	-1.3	57.7	2.7
1929	80.1	1.7	56.1	1.1
1930	81.9	3.5	59.7	4.7
1931	79.4	1.0	57.4	2.4
1932	78.0	-0.4	56.2	1.2
1933	81.3	2.9	56.9	1.9
1934	78.9	0.5	53.2	-1.8
1935	82.4	4.0	62.3	7.3
1936	88.6	10.2	62.4	7.4

A 78.4 B 3.47

A 55.0 B 2.84

A = Mean Value
B = Standard Deviation

TABLE XV (Continued)
DIFFERENCES OF MEAN DAILY MAXIMUM
AND MINIMUM TEMPERATURES FROM
NORMAL
MINNEDOSA

Year	Maximum		Minimum	
	Mean	Diff.	Mean	Diff.
1882	7.3	-1.0	-12.3	0.0
1883	-4.3	-12.6	-26.6	-14.3
1884	3.1	-5.2	-21.5	-9.2
1885	-3.2	-11.5	-25.2	-12.9
1886	-4.8	-13.1	-26.9	-14.6
1887	-1.1	-9.4	-29.4	-17.1
1888	-2.5	-10.8	-23.7	-11.4
1889	19.0	10.7	-6.0	6.3
1890	2.2	-6.1	-20.7	-8.4
1891	20.5	12.2	-0.6	11.7
1892	7.2	-1.1	-16.2	-3.9
1893	6.1	-2.2	-4.7	7.6
1894	6.1	-2.2	-19.4	-7.1
1895	3.1	-5.2	-16.5	-4.2
1896	7.7	-0.6	-12.6	-0.3
1897	12.3	4.0	-12.0	0.3
1898	15.9	7.6	-6.9	5.4
1899	6.8	-1.5	-12.2	0.1
1900	21.2	12.9	-2.2	10.1
1901	9.4	1.1	-10.6	1.7
1902	20.6	12.3	-2.6	9.7
1903	15.1	6.8	-8.2	4.1
1904	11.4	3.1	-11.9	0.4
1905	9.0	0.7	-13.4	-1.1
1906	19.5	11.2	-1.4	10.9
1907	-1.3	-9.6	-20.6	-8.3
1908	20.9	12.6	-3.1	9.2
1909	7.3	-1.0	-13.2	-0.9
1910	15.1	6.8	-3.0	9.3
1911	-0.9	-9.2	-22.0	-9.7
1912	-3.5	-11.8	-21.8	-9.5
1913	1.5	-6.8	-17.9	-5.6
1914	14.3	6.0	-5.8	6.5
1915	10.1	1.8	-8.3	4.0
1916	-0.9	-9.2	-18.6	-6.3
1917	1.9	-6.4	-18.2	-5.9
1918	4.6	-3.7	-14.5	-2.2
1919	19.6	11.3	-0.6	11.7
1920	3.5	-4.8	-14.8	-2.5
1921	15.1	6.8	-3.3	9.0
1922	11.1	2.8	-9.8	2.5
1923	8.0	-0.3	-9.4	2.9
1924	4.6	-3.7	-14.6	-2.3
1925	8.0	-0.3	-10.2	2.1
1926	19.1	10.8	-0.1	12.2
1927	9.1	0.8	-9.7	2.6
1928	16.3	8.0	-1.3	11.0
1929	-1.5	-9.8	-22.4	-10.1
1930	1.2	-7.1	-16.7	-4.4
1931	21.0	12.7	4.9	17.2
1932	14.6	6.3	-6.5	5.8
1933	11.1	2.8	-7.7	4.6
1934	17.8	9.5	-4.0	8.3
1935	2.3	-6.0	-16.7	-4.4
1936	-2.1	-10.4	-22.2	-9.9

A 8.3 B 7.87 A -12.3 B 8.19

A = Mean Value
 B = Standard Deviation

TABLE XV (Continued)
DIFFERENCES OF MEAN DAILY MAXIMUM
AND MINIMUM TEMPERATURES FROM
NORMAL
MINNEDOSA

May				
Year	Maximum		Minimum	
	Mean	Diff.	Mean	Diff.
1881	65.6	2.3	*	*
1882	59.9	-3.4	35.2	-1.7
1883	57.8	-5.5	30.1	-6.8
1884	65.8	2.5	34.8	-2.1
1885	59.6	-3.7	33.2	-3.7
1886	65.2	1.9	35.7	-1.2
1887	67.0	3.7	39.1	2.2
1888	57.4	-5.9	28.7	-8.2
1889	64.1	0.8	34.4	-2.5
1890	55.2	-8.1	29.1	-7.8
1891	65.5	2.2	31.2	-5.7
1892	55.2	-8.1	32.2	-4.7
1893	65.2	1.9	35.9	-1.0
1894	65.0	1.7	38.2	1.3
1895	63.8	0.5	39.0	2.1
1896	63.9	0.6	42.6	5.7
1897	68.0	4.7	38.6	1.7
1898	67.0	3.7	36.6	-0.3
1899	58.3	-5.0	36.0	-0.9
1900	71.4	8.1	41.5	4.6
1901	72.8	9.5	42.6	5.7
1902	64.4	1.1	42.1	5.2
1903	64.4	1.1	38.4	1.5
1904	66.0	2.7	39.7	2.8
1905	61.4	-1.9	37.8	0.9
1906	59.5	-3.8	36.7	-0.2
1907	49.8	-13.5	27.5	-9.4
1908	62.9	-0.4	37.2	0.3
1909	62.8	-0.5	38.2	1.3
1910	61.8	-1.5	31.4	-5.5
1911	64.3	1.0	38.1	1.2
1912	61.8	-1.5	39.2	2.3
1913	*	*	*	*
1914	65.8	2.5	39.3	2.4
1915	64.3	1.0	37.9	1.0
1916	59.8	-3.5	36.6	-0.3
1917	64.3	1.0	33.9	-3.0
1918	60.7	-2.6	33.0	-3.9
1919	70.0	6.7	41.9	5.0
1920	66.2	2.9	38.3	1.4
1921	63.8	0.5	40.0	3.1
1922	66.5	3.2	43.8	6.9
1923	65.5	2.2	38.2	1.3
1924	57.4	-5.9	32.1	4.8
1925	63.1	-0.2	35.9	-1.0
1926	66.9	3.6	41.7	4.8
1927	53.1	-10.2	38.1	1.2
1928	69.2	5.9	39.8	2.9
1929	57.5	-5.8	33.5	-3.4
1930	59.0	-4.3	35.8	-1.1
1931	64.0	0.7	35.2	-1.7
1932	67.6	4.3	39.8	2.9
1933	64.5	1.2	40.7	3.8
1934	69.8	6.5	39.6	2.7
1935	59.8	-3.5	36.9	0.0
1936	69.6	6.3	41.9	5.0

A 63.3 B 4.64 A 36.9 B 3.83

A = Mean Value

*Records incomplete

B = Standard Deviation

TABLE XV (Concluded)
DIFFERENCES OF MEAN DAILY MAXIMUM
AND MINIMUM TEMPERATURES FROM
NORMAL
MINNEDOSA

July				
Year	Maximum		Minimum	
	Mean	Diff.	Mean	Diff.
1881	76.9	0.2	53.6	2.0
1882	72.3	-4.4	49.5	-2.1
1883	70.8	-5.9	45.1	-6.5
1884	74.8	-1.9	44.0	-7.6
1885	72.1	-4.6	48.2	-3.4
1886	79.6	2.9	51.1	-0.5
1887	74.0	-2.7	47.8	-3.8
1888	74.7	-2.0	49.0	-2.6
1889	77.7	1.0	48.9	-2.7
1890	78.2	1.5	50.0	-1.6
1891	72.5	-4.2	45.1	-6.5
1892	77.9	1.2	48.1	-3.5
1893	78.3	1.6	51.3	-0.3
1894	80.7	4.0	53.3	1.7
1895	75.1	-1.6	51.0	-0.6
1896	76.1	-0.6	51.9	0.3
1897	78.0	1.3	53.5	1.9
1898	74.5	-2.2	52.5	0.9
1899	78.7	2.0	52.1	0.5
1900	75.3	-1.4	51.5	-0.1
1901	77.7	1.0	56.3	4.7
1902	76.7	0.0	52.9	1.3
1903	73.3	-3.4	50.9	-0.7
1904	73.5	-3.2	48.1	-3.5
1905	75.7	-1.0	50.7	-0.9
1906	77.4	0.7	54.5	2.9
1907	74.4	-2.3	49.8	-1.8
1908	77.5	0.8	52.0	0.4
1909	76.9	0.2	54.0	2.4
1910	79.8	3.1	52.2	0.6
1911	72.0	-4.7	48.5	-3.1
1912	72.8	-3.9	51.2	-0.4
1913	72.6	-4.1	49.1	-2.5
1914	84.6	7.9	56.5	4.9
1915	70.7	-6.0	48.4	-3.2
1916	79.1	2.4	57.6	6.0
1917	82.9	6.2	52.0	0.4
1918	76.3	-0.4	47.4	-4.2
1919	80.6	3.9	52.7	1.1
1920	79.2	2.5	51.4	-0.2
1921	81.1	4.4	54.8	3.2
1922	75.2	-1.5	50.5	-1.1
1923	76.4	-0.3	56.1	4.5
1924	75.7	-1.0	54.4	2.8
1925	74.7	-2.0	51.6	0.0
1926	78.6	1.9	52.5	0.9
1927	72.4	-4.3	51.9	0.3
1928	73.2	-3.5	54.4	2.8
1929	79.8	3.1	51.4	-0.2
1930	78.9	2.2	54.3	2.7
1931	76.9	0.2	53.2	1.6
1932	76.5	-0.2	52.5	0.9
1933	79.8	3.1	53.0	1.4
1934	78.0	1.3	50.2	-1.4
1935	79.0	2.3	59.1	7.5
1936	86.9	10.2	58.2	6.6
A 76.7		B 3.33	A 51.6	B 3.12

A = Mean Value
 B = Standard Deviation

TABLE XVI

SUNNIEST AND GLOOMIEST MONTHS ON RECORD

SUNNIEST				GLOOMIEST		
Year		Hours Sunshine	% of Possible	Year	Hours Sunshine	% of Possible
Brandon (1891-1935)						
January...	1929	159	59.6	1914	74	27.7
February...	1908	168	57.4	1915	86	29.3
March...	1895	215	58.4	1902	106	28.8
April...	1900	265	64.4	1893	127	30.8
May...	1901	330	69.4	1892	130	27.3
June...	1900	296	60.8	1915	164	33.8
July...	1936	337	69.0	1912	166	35.0
August...	1933	302	68.0	1912	118	26.6
September...	1909	243	64.6	1915	107	26.5
October...	1910	189	57.0	1908	90	27.1
November...	1916	133	49.3	1892	45	16.7
December...	1927	123	49.0	1909	49	19.5
Winnipeg (1881-1936)						
January...	1890	156	58.6	1931	64	24.0
February...	1907	186	66.3	1930	89	31.7
March...	1895	221	60.0	1903	103	28.0
April...	1900	306	74.4	1924	119	29.0
May...	1917	357	75.0	1927	127	26.7
June...	1886	320	65.8	1925	173	35.6
July...	1934	348	71.3	1912	178	36.5
August...	1930	313	70.5	1912	161	36.3
September...	1897	243	64.6	1912	113	30.0
October...	1914	184	55.5	1917	72	21.7
November...	1886	179	55.2	1915	43	15.9
December...	1886	135	53.4	1912	32	12.8
Indian Head (1891-1936)						
January...	1902	107	40.5	1923	26	9.9
February...	1931	148	52.8	1925	59	21.0
March...	1915	196	53.3	1902	77	20.9
April...	1905	245	59.4	1894	121	29.3
May...	1936	293	61.3	1927	114	23.8
June...	1896	296	60.6	1901	147	30.0
July...	1929	337	68.7	1912	141	28.7
August...	1909	321	72.0	1912	131	29.4
September...	1909	234	62.0	1901	83	22.0
October...	1907	183	55.5	1898	64	19.4
November...	1930	116	43.3	1921	27	10.1
December...	1923	98	39.5	1925	12	4.8

TABLE XVII

PERCENTAGE FREQUENCY OF WINDS AT SPEED INDICATED

Miles per Hour	Winnipeg											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Calms.....	9.1	10.5	8.5	6.7	6.5	8.2	9.7	9.6	6.6	7.1	7.4	10.7
4 - 15	71.8	71.0	70.5	68.2	70.7	73.6	75.6	76.5	73.5	70.7	71.5	72.5
15 - 31	18.7	18.1	20.4	24.3	22.3	18.0	14.5	13.7	19.7	21.8	20.8	16.5
31 - 47	0.4	0.4	0.5	0.8	0.5	0.2	0.2	0.2	0.2	0.4	0.3	0.3
47 +	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Qu'Appelle												
Calms.....	11.5	10.3	8.7	7.3	7.8	9.7	12.1	12.4	8.6	6.7	8.2	11.3
4 - 15	73.2	76.4	74.9	74.2	75.4	78.9	80.7	79.9	80.5	80.1	77.8	75.4
15 - 31	15.2	13.1	16.2	18.3	16.7	11.4	7.2	7.8	10.8	13.2	13.9	13.2
31 - 47	0.1	0.2	0.2	0.2	0.1	*	*	*	0.1	*	0.1	0.1
47 +	0.0	0.0	0.0	*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note.—Frequency by directions will be found in the charts.

*Records not complete

Errata Note—Chart No. 74. Bar histograms for July, August, Sept., Winnipeg, miles per hour 15 to 31 are incorrectly shown.

TABLE XVIII

WINNIPEG, MAN.
UPPER AIR WIND FREQUENCY
 500 Metres above Sea or 880 Feet above Winnipeg

Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JANUARY									
10 — 35	5	0	0	5	10	5	5	32	37
35 — 70	0	0	0	0	0	0	0	0	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	5	0	0	5	10	5	5	32	37
FEBRUARY									
10 — 35	0	0	0	0	10	10	20	40	20
35 — 70	0	0	0	0	0	0	0	0	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	0	0	0	0	10	10	20	40	20
MARCH									
10 — 35	13	13	0	0	22	4	13	17	13
35 — 70	0	0	0	0	0	0	0	4	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	13	13	0	0	22	4	13	21	13
APRIL									
10 — 35	25	0	0	0	8	13	4	8	34
35 — 70	0	0	0	0	0	0	0	8	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	25	0	0	0	8	13	4	16	34
MAY									
10 — 35	9	17	4	9	4	13	5	13	13
35 — 70	0	0	0	4	0	0	4	0	
70 — 105	0	0	0	0	5	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	9	17	4	13	9	13	9	13	13
JUNE									
10 — 35	0	8	4	8	12	13	17	17	21
35 — 70	0	0	0	0	0	0	0	0	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	0	8	4	8	12	13	17	17	21

TABLE XVIII (Continued)

WINNIPEG, MAN.
UPPER AIR WIND FREQUENCY
 500 Meters above Sea or 880 Feet above Winnipeg

Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JULY									
10 — 35.....	19	0	8	8	11	4	4	15	31
35 — 70.....	0	0	0	0	0	0	0	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals	19	0	8	8	11	4	4	15	31
AUGUST									
10 — 35.....	4	4	8	8	13	0	12	13	34
35 — 70.....	0	0	0	4	0	0	0	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals	4	4	8	12	13	0	12	13	34
SEPTEMBER									
10 — 35.....	4	4	4	4	25	8	8	21	21
35 — 70.....	0	0	0	0	0	0	0	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals	4	4	4	4	25	8	8	21	21
OCTOBER									
10 — 35.....	9	0	0	4	9	9	13	13	13
35 — 70.....	0	0	0	0	13	4	0	4	
70 — 105.....	9	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals	18	0	0	4	22	13	13	17	13
NOVEMBER									
10 — 35.....	22	0	0	0	4	22	9	4	1
35 — 70.....	9	0	0	0	4	9	0	13	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals	31	0	0	0	8	31	9	17	4
DECEMBER									
10 — 35.....	0	0	0	0	8	8	15	15	23
35 — 70.....	0	0	0	0	23	0	0	0	
70 — 105.....	0	0	0	0	0	0	0	8	
Over 105.....	0	0	0	0	0	0	0	0	
Totals	0	0	0	0	31	8	15	23	23

TABLE XVIII (Continued)

WINNIPEG, MAN.
UPPER AIR WIND FREQUENCY
1000 Metres above Sea or 1520 Feet above Winnipeg

Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JANUARY									
10 — 35...	20	7	0	0	0	13	7	33	13
35 — 70...	0	0	0	0	7	0	0	0	
70 — 105...	0	0	0	0	0	0	0	0	
Over 105 ..	0	0	0	0	0	0	0	0	
Totals	20	7	0	0	7	13	7	33	13
FEBRUARY									
10 — 35.	28	5	0	0	5	0	17	28	11
35 — 70.....	0	0	0	0	0	0	0	5	
70 — 105 ..	0	0	0	0	0	0	0	0	
Over 105 ..	0	0	0	0	0	0	0	0	
Totals	28	5	0	0	5	0	17	33	11
MARCH									
10 — 35..	20	10	0	0	15	5	5	25	0
35 — 70...	5	0	0	0	5	0	5	0	
70 — 105..	0	0	0	0	0	0	0	0	
Over 105 ..	0	0	0	0	0	0	0	5	
Totals	25	10	0	0	20	5	10	30	0
APRIL									
10 — 35	35	4	0	0	5	5	9	9	21
35 — 70 ..	4	0	0	0	4	4	0	0	
70 — 105 ..	0	0	0	0	0	0	0	0	
Over 105 ..	0	0	0	0	0	0	0	0	
Totals	39	4	0	0	9	9	9	9	21
MAY									
10 — 35.	14	9	9	9	9	9	5	9	18
35 — 70...	4	0	0	0	0	0	4	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105 ..	0	0	0	0	0	0	0	0	
Totals	18	9	9	9	9	9	9	9	18
JUNE									
10 — 35 ..	13	9	4	0	9	13	13	13	9
35 — 70 ..	0	0	0	4	4	4	0	4	
70 — 105 ..	0	0	0	0	0	0	0	0	
Over 105 ..	0	0	0	0	0	0	0	0	
Totals	13	9	4	4	13	17	13	17	9

TABLE XVIII (Continued)

WINNIPEG, MAN.
UPPER AIR WIND FREQUENCY
1000 Metres above Sea or 1520 Feet above Winnipeg

Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JULY									
10 — 35.....	12	8	4	15	12	11	4	11	19
35 — 70.....	0	0	0	0	0	0	0	4	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	12	8	4	15	12	11	4	15	19
AUGUST									
10 — 35.....	5	0	14	5	14	5	10	19	28
35 — 70.....	0	0	0	0	0	0	0	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	5	0	14	5	14	5	10	19	28
SEPTEMBER									
10 — 35.....	8	8	0	4	17	0	8	13	21
35 — 70.....	0	0	0	0	12	4	0	4	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	8	8	0	4	29	4	8	17	21
OCTOBER									
10 — 35.....	21	0	0	5	5	10	16	11	5
35 — 70.....	0	0	0	0	5	11	5	5	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	21	0	0	5	10	21	21	16	5
NOVEMBER									
10 — 35.....	10	5	0	0	0	5	20	20	5
35 — 70.....	10	0	0	0	0	5	10	5	
70 — 105.....	0	0	0	0	0	0	0	5	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	20	5	0	0	0	10	30	30	5
DECEMBER									
10 — 35.....	0	0	0	0	9	9	9	0	9
35 — 70.....	0	0	0	0	9	0	0	45	
70 — 105.....	0	0	0	0	0	0	0	10	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	0	0	0	18	9	9	55	9

TABLE XVIII (Continued)

WINNIPEG, MAN.									
UPPER AIR WIND FREQUENCY									
2000 Metres above Sea or 5800 Feet above Winnipeg									
Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JANUARY									
10 — 35	15	0	0	0	0	8	15	46	8
35 — 70	0	0	0	0	0	0	0	8	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	15	0	0	0	0	8	15	54	8
FEBRUARY									
10 — 35	6	0	0	0	0	0	44	31	13
35 — 70	0	0	0	0	0	0	0	6	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	6	0	0	0	0	0	44	37	13
MARCH									
10 — 35	25	8	0	0	0	8	25	0	0
35 — 70	8	0	0	0	0	0	17	8	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	33	8	0	0	0	8	42	8	0
APRIL									
10 — 35	13	6	6	0	0	6	38	31	0
35 — 70	0	0	0	0	0	0	0	0	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	13	6	6	0	0	6	38	31	0
MAY									
10 — 35	11	11	0	0	21	5	16	21	10
35 — 70	0	0	0	0	0	0	0	5	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	11	11	0	0	21	5	16	26	10
JUNE									
10 — 35	15	5	5	0	0	10	15	20	10
35 — 70	0	0	0	5	0	10	0	5	
70 — 105	0	0	0	0	0	0	0	0	
Over 105	0	0	0	0	0	0	0	0	
Totals	15	5	5	5	0	20	15	25	10

TABLE XVIII (Continued)

WINNIPEG, MAN.
UPPER AIR WIND FREQUENCY
2000 Metres above Sea or 5800 Feet above Winnipeg

Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JULY									
10 — 35.....	12	4	0	4	16	16	4	16	20
35 — 70.....	0	0	0	0	4	0	0	4	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	12	4	0	4	20	16	4	20	20
AUGUST									
10 — 35.....	17	11	5	0	11	5	11	6	28
35 — 70.....	0	0	0	0	0	0	6	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	17	11	5	0	11	5	17	6	28
SEPTEMBER									
10 — 35.....	10	0	0	5	5	5	30	20	10
35 — 70.....	0	0	0	0	5	5	5	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	10	0	0	5	10	10	35	20	10
OCTOBER									
10 — 35.....	0	0	0	0	6	7	27	26	0
35 — 70.....	7	0	0	0	0	6	0	20	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	7	0	0	0	6	13	27	46	0
NOVEMBER									
10 — 35.....	0	0	0	0	0	6	19	19	0
35 — 70.....	19	0	0	0	0	0	12	19	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	6	0	0	0	0	0	0	0	
Totals.....	25	0	0	0	0	6	31	38	0
DECEMBER									
10 — 35.....	0	0	0	0	11	0	22	11	0
35 — 70.....	0	0	0	0	0	11	11	33	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	0	0	0	11	11	33	44	0

TABLE XVIII (Continued)

WINNIPEG, MAN.
UPPER AIR WIND FREQUENCY
3000 Metres above Sea or 9082 Feet above Winnipeg

Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JANUARY									
10 — 35.....	12	0	0	0	0	0	13	50	0
35 — 70.....	0	0	0	0	0	0	0	25	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	12	0	0	0	0	0	13	75	0
FEBRUARY									
10 — 35.....	0	0	0	0	0	0	17	25	25
35 — 70.....	8	0	0	0	0	0	25	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	8	0	0	0	0	0	42	25	25
MARCH									
10 — 35.....	0	14	0	0	0	14	14	44	0
35 — 70.....	0	0	0	0	0	0	0	14	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	14	0	0	0	14	14	58	0
APRIL									
10 — 35.....	8	9	9	0	0	0	8	25	0
35 — 70.....	8	0	0	0	0	0	25	8	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	16	9	9	0	0	0	33	33	0
MAY									
10 — 35.....	8	8	8	0	17	0	17	17	8
35 — 70.....	0	0	0	0	0	8	0	8	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	8	8	8	0	17	8	17	25	8
JUNE									
10 — 35.....	0	0	0	0	0	14	43	28	0
35 — 70.....	0	0	0	0	0	14	0	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	0	0	0	0	28	43	28	0

TABLE XVIII (Concluded)

WINNIPEG, MAN.
UPPER AIR WIND FREQUENCY
3000 Metres above Sea or 9082 Feet above Winnipeg

Wind-Speed Miles per Hour	N	NE	E	SE	S	SW	W	NW	Below 10 Miles per Hour
JULY									
10 — 35.....	12	0	0	6	6	29	6	23	0
35 — 70.....	0	0	0	0	0	6	0	12	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	12	0	0	6	6	35	6	35	0
AUGUST									
10 — 35.....	0	0	0	0	0	21	50	14	14
35 — 70.....	0	0	0	0	0	0	0	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	0	0	0	0	21	50	14	14
SEPTEMBER									
10 — 35.....	0	0	0	0	0	0	42	8	16
35 — 70.....	0	0	0	0	8	0	25	0	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	0	0	0	8	0	67	8	16
OCTOBER									
10 — 35.....	0	0	0	0	0	11	11	33	0
35 — 70.....	0	0	0	0	0	0	11	33	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	0	0	0	0	11	22	66	0
NOVEMBER									
10 — 35.....	0	0	0	0	0	0	0	12	0
35 — 70.....	13	0	0	0	0	0	25	50	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	13	0	0	0	0	0	25	62	0
DECEMBER									
10 — 35.....	0	0	0	0	0	0	17	0	17
35 — 70.....	0	0	0	0	0	17	16	33	
70 — 105.....	0	0	0	0	0	0	0	0	
Over 105.....	0	0	0	0	0	0	0	0	
Totals.....	0	0	0	0	0	17	33	33	17

END